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CORRIGENDA.

REVIEW, December, 1922:

Chart XII (L–168), the barometric pressure at Barbuda on the 16th *should be* 28.58. Likewise at Bermuda on the 21st the pressure *should be* 28.57.

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ALFRED J. HENRY, Editor.

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HISTORY OF RADIO IN RELATION TO THE WORK OF THE WEATHER BUREAU.

By E. B. CALVERT, Meteorologist in Charge, Forecast Division.

[Weather Bureau, Washington, February 20, 1923.]

SYNOPSIS.

The purpose of this paper is to assemble facts relating to the history, progress, and present usage of radio in relation to the work of the Weather Bureau. The Weather Bureau was the pioneer of all agencies of the United States Government in investigations and experiments in wireless telegraphy. The investigations were undertaken because it was foreseen that this form of communication presented a field of opportunity to meteorology in securing current weather information from inaccessible places and ships, the providing of storm warnings to vessels at sea, and supplementing or replacing the Weather Bureau system of collecting weather reports by telegraph and cable.

Radio has been utilized continuously by the Weather Bureau for more than 20 years, and it now plays a large and indispensable part in its activities.

CHRONOLOGY.

1895 Marconi begins his investigations in wireless telegraphy.

1899 Marconi succeeds in transmitting wireless messages across the English Channel.

1900 (Jan. 19). Professor R. A. Fessenden engaged by the Weather Bureau to conduct wireless telegraph experiments.

1902 (July). First application of radio communication to storm-warning work.

1904 (June 24). Inter-Departmental Board on Wireless Telegraph appointed by the President.

1904 (July 29). Weather Bureau discontinued radio experiments and operations.

1904 (Nov. 30). Navy takes up radio work for the Weather Bureau.

1905 (July 1). Lighthouse Board cooperates with Weather Bureau in collecting messages from observers at sea.

1905 (Dec. 1). First weather map prepared at sea from radio reports.

1905 (Dec. 3). First observation by radio from vessel in the Atlantic Ocean.

1906 Establishment of vessel-weather service.

1906 (June 28). International Conference on wireless telegraphy at Berlin.

1907 (July 18). First observation by radio from a vessel in the Pacific Ocean.

1907 (Nov. 1). Radio first used in securing reports from Alaska.

1909 (Aug. 26). First radio report from vessel in vicinity of hurricane.

1912 (June–July). International Radio Telegraph Conference, London.

1913 (July 15). Inauguration of broadcasting of daily Weather Bureau bulletins by naval radio stations.

1914 (January). First daily broadcasts of forecasts in the several States by radiotelegraph.

1914 (July 1). Similar service begun for the region of the Great Lakes.

1915 (Oct. 21). Inter-Departmental Committee on radio legislation.

1919 (Jan. 17). First weather reports to France by radio.

1920 (Sept. 14). Conference with delegates to Radio Protocol.

1920 (Nov. 20). Inauguration of radio weather broadcasting for the hurricane season at San Juan, P. R.

1921 (Jan. 1). First daily radiophone broadcasts of forecasts.

1921 (May 17). Inter-Departmental Board to consider radio and telegraph service for the Government.

1921 (June 1). First radio weather bulletins for benefit of aviation.

1921 (June 1). United States Shipping Board cooperates in obtaining daily meteorological observations on all its ships and forwarding the reports by radio to the Weather Bureau.

1921 (June 10). Localized radio weather broadcast service begun for the Atlantic and Gulf coasts and the Great Lakes.

1923 (Feb. 15). Inauguration of radiophone weather broadcasting through United States naval radio station at Arlington.

EARLY HISTORY AND EXPERIMENTS.

Marconi began his investigations in wireless telegraphy in 1895, and in March, 1899, he succeeded in transmitting messages by this means across the English Channel from Dover to Boulogne. The Weather Bureau was interested immediately in these investigations because wireless communication presented a field of opportunity to meteorology in the obtaining of current weather information from places inaccessible by telegraph, telephone, or cable, in the transmission of forecasts and warnings to such places, and, further, because it offered a prospect of supplementing or replacing at less cost its extensive system of collecting weather reports by telegraph circuits. Therefore, a few months after Marconi had demonstrated the practicability of wireless communication, the Weather Bureau formulated plans for investigation looking toward the development of apparatus and extension of knowledge of the underlying principles of the science.

Prof. Reginald A. Fessenden, then a member of the faculty of the Western University of Pennsylvania, at Allegheny, was employed by the Weather Bureau to conduct the experiments. They were begun January 19, 1900. Thus the Weather Bureau became the pioneer of all agencies of the United States Government in investigations and experimentations in wireless telegraphy.

Special stations for the work were established at Hatteras and Roanoke Island, N. C., 47 miles apart. These points were selected because of the advantages

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presented by the intervening space being entirely water, and for the further reason that the Weather Bureau owned and operated cable and land-line connections between the two points, which provided immediate means of checking the results of the work. A number of forms of receivers were devised and tested, and communication between the two stations was accomplished in 1901 by means of a hot-wire receiver or boloscope, and without the use of the "coherer" which Marconi had utilized. During the winter and early spring it gave excellent results and messages were transmitted with a rapidity almost equal to that of the ordinary telegraph. Successful tests were made in the spring of 1902 before representatives of the Army and Navy. It was thought that this receiver would replace all others in use. However, during the summer the atmospheric electric conditions frequently caused the minute platinum loops, on which the action of the boloscope depended, to burn out when connection was made with a vertical wire.

Professor Fessenden developed and patented a number of valuable devices which were used in wireless telegraphy for many years. Unfortunately for the Government, the contract entered into between the Secretary of Agriculture and Professor Fessenden provided that only the Weather Bureau should have free use and right to the latter's patents. The Weather Bureau received no substantial benefits from the patents because it was disengaged from wireless experimentations and transmission activities in 1904, and litigation efforts to secure free use of them by other branches of the Government were unsuccessful.

Professor Fessenden continued his investigations until August 31, 1902, when he resigned. After that date they were continued under the direction of Mr. Alfred H. Thiessen, who had been Professor Fessenden's assistant. Mr. Thiessen's experimental work was transferred to the Pacific coast and wireless stations were established at Point Reyes Light, Calif., and on southeast Farallon Island. Regular communication was established between these points and effectively used in the transmission of weather observations and reports of ships bound for the Golden Gate.

Inter-departmental Board on Wireless Telegraph.—In the meantime the Army and Navy became engaged in wireless telegraph work and investigations. Developments were rapid and it soon became apparent that confusion and unsatisfactory conditions would arise should many Government agencies work independently along the same lines. Under date of June 24, 1904, President Roosevelt appointed Rear Admiral Robley D. Evans, representing the Department of Commerce and Labor; Rear Admiral Henry N. Manney and Lieut. Commander Joseph L. Jayne, representing the Navy Department; Brig. Gen. Adolphus W. Greely, representing the War Department; and Prof. Willis L. Moore, Chief of the Weather Bureau, representing the Department of Agriculture, as a board "to consider the entire question of wireless telegraphy in the service of the National Government," with directions that it submit a full report to him.

The board submitted a unanimous report on July 12, 1904. By order of July 29, 1904, the President directed that "the several departments concerned put its recommendations into effect." Under the terms of the order the Weather Bureau ceased its wireless experiments and operations. Such work was assigned to the Navy on coasts and the Great Lakes, and to the Army in the interior. It provided that "the Navy Department shall, without charge to the Agricultural Department, receive and promptly transmit to the oceans or to islands, or to other places where the information can be made useful, the storm warnings of the Weather Bureau."

The members of this board, as shown by their report, had such a clear vision of the potentialities of radio communication and of the necessity for its regulation, and were so prophetic of the confused conditions that now confront this country and how to remedy them, that it is quoted in full.

REPORT OF INTER-DEPARTMENTAL BOARD APPOINTED BY PRESIDENT ROOSEVELT.

LIGHTHOUSE BOARD ROOM,
Washington, July 12, 1904.

The board first met in the Lighthouse Board room, in obedience to the order of the President and pursuant to the call of the chairman, at 11 a. m., July 6, 1904. Present, all the members.

The chairman requested Lieutenant Commander Jayne to act as recorder, and then read the letter appointing the board, a copy of which is prefixed and marked "A," and the inclosures, marked "B" to "J," inclusive.

After the reading of the memorandum from the Secretary of Agriculture, marked "D," Professor Moore stated that Mr. Fessenden had, since it was written, made a satisfactory settlement of the claims against him by assigning the patent rights in question to the Department of Agriculture, Weather Bureau.

The board thoroughly discussed and maturely considered the questions before it at its meetings held from time to time, all the members being present at each meeting.

The following was found to be the status regarding Government wireless telegraph stations:

(*a*) The Department of Commerce and Labor has established no stations, but permission has been granted to other departments to erect 10 on lighthouse reservations and on the Nantucket Shoals Lightship and its relief.

(*b*) The Army has operated six stations and is preparing to install two others in Alaska. The urgent necessity for the stations in Alaska has caused the temporary removal of the apparatus from two of the first mentioned, but it is in process of replacement. Four other Army stations have been proposed, but for two of these the Chief Signal Officer thinks that the proposed naval stations in the same localities, if available to the Army, would make duplication unnecessary. The Army also has one portable train for use in maneuvers or for other military purposes.

(*c*) The Department of Agriculture made valuable and extensive experimentation, and has established two stations and contemplated establishing others at prominent points along the coast lines.

(*d*) The Navy Department has established 20 shore stations. The apparatus has been removed from 1 of these but it will be replaced in a few days. Arrangements are being made for the establishment of 10 more in the near future, a complete equipment, or some portion of it, having been ordered for each one. This includes the 2 lightships that take turns on Nantucket Shoals. In addition to these 30 stations, it is proposed to establish about 50 more on shore and to start on the more important of these at an early date.

The Navy Department has entered into a very important contract for the equipment of long-distance stations at Key West, Guantanamo, points to be determined in Porto Rico and in the Panama Canal Zone, and Pensacola. Satisfactory communication is to be established between all of the first four and between Key West and Pensacola. Communication from any one of these stations to ships at any points between it and a communicating station is also to be established.

Twenty-four naval ships have already been equipped and 10 others are to be equipped immediately, or before the completion of the repairs which they are undergoing. It is proposed to equip 68 others after the report of the board which is now conducting test of various systems has been acted upon, making a total of 102.

One torpedo-boat outfit has been ordered for trial. If this apparatus is successful a number of torpedo-boat destroyers and small gunboats may be equipped, making the total number considerably larger.

With these small vessels provided with wireless apparatus, there would be about 200 naval stations on shore and afloat.

(*e*) The Treasury Department, while having under consideration wireless installations for the Life Saving Service and the Revenue Marine Service, has established no stations, but has relied on a leased commercial wireless system.

The following was found to be the status of private stations:

The Marconi Co. has a long-distance station on Cape Cod for communicating across the Atlantic, and two others of comparatively short

range on Long Island. The board understands that that company proposes to establish numerous stations along the Atlantic and Pacific coasts.

The New York Herald Co. has a station on the lighthouse reservation on Sankaty Head, Nantucket Island, and has been permitted to maintain stations on the two lightships which relieve each other on Nantucket Shoals. These privileges have been withdrawn, however, owing to the refusal of the Marconi Co., which operated them for the Herald, to receive wireless messages from vessels using other systems.

The American De Forest Wireless Telegraph Co. and the National Electric Signal Co. (Fessenden system) have stations in the vicinity of New York and both propose to establish a chain of them along the coast. The former company has already begun operations at Cape Hatteras and at Key West, and has announced that they propose to establish several stations to bridge the Pacific and make foreign connections. It has also established several stations away from the seacoast, especially on the Great Lakes, and is planning to have a regular interior system, according to one of its officers.

The Fessenden system has stations in Philadelphia and Washington. Fessenden states that his company is negotiating for permission to establish communication with Bermuda.

The Providence Journal maintains several stations in the vicinity of Narragansett Bay and there are several other systems which are at present not very active.

On the Pacific coast the Pacific Wireless Telegraph Co. has several stations and has been making persistent efforts to obtain authority to establish stations on the lighthouse reservations, Farallon Islands, and at other prominent Government reservations along the Pacific coast.

There is an interisland system operated in Hawaii.

A number of trans-Atlantic liners are using the Marconi apparatus. Few coasting vessels are using any system, but the indications are that this method of communication will come into quite common use when the shipowners feel that conditions are favorable.

The Navy Department has at times been very seriously interfered with in the vicinity of New York and Boston and there are already so many stations in the vicinity of Newport that an effort has been made by the officer in charge of the torpedo station to establish a tentative arrangement whereby the various stations will interfere as little as possible with each other.

Reports from the naval wireless station on Cape Cod indicate that on one occasion that station was temporarily crippled, very probably by heavy sending at the Marconi long-distance station a few miles away.

It would appear that the Weather Bureau already has a station at one of the most important points on the Pacific coast, where the Navy Department desires to erect one and equip it with more powerful apparatus than now in use by the Weather Bureau. The Weather Bureau also intended putting in new apparatus, it having been demonstrated that that now in use is unable to communicate with the nearest naval station in San Francisco Bay, although the latter has sufficient power to reach far beyond the Farallons. This is one of the places where the Pacific Wireless Telegraph Co. is so anxious to locate.

The Weather Bureau also contemplated establishing stations at prominent points where the Navy Department already has stations in operation or proposed to establish them. Most of the stations proposed by the wireless telegraph companies are to be located at prominent points where Government stations are already established or proposed. This state of affairs seems to demand prompt action to avoid most unfortunate confusion and unnecessary duplication.

As a first step toward avoiding this condition the board adopted the following resolution:

"*Resolved*, That all installations of Government wireless telegraph stations be suspended, except at stations now under contract, until the final report of the board is acted upon by the President. That all departments of the Government interested in wireless telegraphy should refuse to allow any private company to install a station on any Government reservation until so authorized by proper authority."

CONCLUSIONS.

The conclusions of the board are:

That the science of wireless telegraphy has been advanced by the able and persistent work of the Signal Corps of the Army and the Weather Bureau of the Department of Agriculture, as well as by the experimental work of the Navy Department;

That wireless telegraphy is of paramount interest to the Government through the Navy Department, and that its use by the Signal Corps of the Army for communication between military posts of the Army and other necessary links will be necessary both in peace and war, and that such use shall be unrestricted. When interference seems probable between stations of the Navy and War Departments, the question involved shall be mutually settled by representatives of the two departments.

That coastwise wireless telegraphy is not a necessity for the work of the Weather Bureau of the Department of Agriculture, provided that the necessary meteorological data for that department can be collected by the stations of the Navy Department from ships at sea and by them sent to the Weather Bureau of the Department of Agriculture.

That the maintenance of a complete coastwise system of wireless telegraphy by the Navy Department is necessary for the efficient and economical management of the fleets of the United States in time of peace and their efficient maneuvering in time of war.

That the best results can be obtained from stations under the jurisdiction of one department of the Government only, and that representatives of more than one department should not be quartered at any station.

And, finally, the board concludes that the Government must take the necessary steps to regulate the establishment of commercial wireless-telegraph stations among the States and between nations.

RECOMMENDATIONS.

In order that the above conclusions may be carried into effect, the board recommends—

That the Signal Corps of the Army be authorized under its chief to establish from time to time such wireless stations as he may deem necessary, and that they do not interfere with the coastwise wireless-telegraph system of the Government under control of the Navy Department; and further, that the Chief Signal Officer be requested to inform the Navy Department what stations of its system may be utilized to transmit messages for the Signal Corps or other bureaus of the War Department, and that representatives of the Signal Corps of the Army and the Bureau of Equipment of the Navy Department be at once requested to draw up such rules as will insure the efficient and harmonious carrying into effect of the above recommendations.

That the necessary steps be taken to have the Weather Bureau of the Department of Agriculture turn over to the Navy Department all coastwise wireless-telegraph apparatus now under its control, and such material as it may have in its possession which can be utilized by the Bureau of Equipment of the Navy Department, and that proper transfers of funds for this purpose be made.

That the Weather Bureau of the Department of Agriculture furnish to the Hydrographic Office of the Navy, and to the naval wireless-telegraph stations, or to other portions of the public service, such meteorological data as it or they may desire at no cost to them.

That the Department of Agriculture shall continue the work of its meteorological vessel-reporting and storm-warning stations, as now constituted and provided for by law, and continue the control of seacoast telegraph systems, except wireless systems.

That the necessary steps be taken that the Navy Department may equip and install a complete coastwise wireless-telegraph system covering the entire coasts of the United States, its insular possessions, and the Canal Zone in Panama.

That the Navy Department be directed to receive from the Signal Corps of the Army, at such points as may be requested by the Chief Signal Officer of the Army, all messages for Army posts within their radii, and transmit them, under such rules as may be agreed upon by the representatives of the Signal Corps and Bureau of Equipment, without cost to the Signal Corps of the Army.

That all meteorological reports from vessels of war or commerce or other sailing craft, now being forwarded direct to the Hydrographic Office of the Navy, shall be forwarded direct to the Weather Bureau, and the control of ocean meteorology be transferred to the Department of Agriculture, which already has ample law for doing this work.

That the estimates for the support of the Hydrographic Office of the Navy, or any other office of the Navy, for the next and succeeding fiscal years, do not contain any provision for the making of ocean forecasts, or for the publication of meteorological data, other than such as may be needed by the hydrographer of the Navy for use of the pilot and other charts, which data shall be furnished by and credited to the Weather Bureau.

That it is the opinion of this board that no meteorological work need or should be done by any portion of the Navy for the purpose of publication, or for the making of forecasts or storm warnings; that all such duties, being purely civil, should devolve upon the Weather Bureau of the Department of Agriculture in accordance with the organic act creating that bureau;

That the wireless stations of the Navy Department shall, without charge to the Agricultural Department, receive and promptly transmit to the ocean or to islands, or to other places where the information can be made useful, the storm warnings of the Weather Bureau;

That the Navy Department shall request all vessels having the use of its wireless stations for the receipt of messages, to take daily meteorological observations of the weather when within communicating range and to transmit such observations to the Weather Bureau, through naval wireless stations, at least once daily, and transmit observations oftener when there is a marked change in the barometer; and that there shall be no charge against the Agricultural Department for these observations, or for the transmission thereof;

That representatives of the Department of Agriculture and the Bureau of Equipment of the Navy Department be directed to prepare the necessary rules for the harmonious and efficient carrying on of the above recommendations.

We recommend that as fast as the naval wireless telegraph stations are put in operation the Navy Department be directed to receive and transmit through these stations, free of charge, all wireless messages to or from ships at sea, provided such stations do not come in competition with commercial stations, until such time as Congress may enact the necessary legislation governing this subject.

In asking for legislation on this point, the board desires to invite attention to the fact that where wireless stations are needed for the merchant marine, as a rule the Navy will also require them. The board believes it to be in the interest not only of governmental, but public economy and efficiency, to permit the naval stations to handle the public service, for the present state of the art but one station is desirable, for the public interests in such places. As the needs of the Navy are paramount on account of the problem of national defense, private stations should not be allowed to locate to the disadvantage of the former. Moreover, there is at present no public need for multiplication of stations at these points.

It is admitted, however, that there may be special cases where private stations can serve a useful purpose, and the board believes that the Department of Commerce and Labor should have the duty of issuing licenses in such cases under such regulations as will prevent interference with stations necessary to the national defense. All private stations in the interior of the country should also be under supervision of the Department of Commerce and Labor.

This method of placing private stations under full Government supervision is desirable in order to regulate them for their mutual and the public welfare, as well as from considerations of national defense. Aside from the necessity of providing rules for the practical operation of such stations, it seems desirable that there should be some wholesome supervision of them to prevent the exploitation of speculative schemes based on a public misconception of the art.

It is believed that invention and private enterprise should be encouraged in every legitimate way, and it is the policy of the Navy Department to do this. It has the means of assisting inventors that no other department has, and it believes that in order for it to lead the navies of the world in this matter, which is of great importance to the national defense, that every reasonable facility should be given inventors, while at the same time it is working out the problems of the application of their inventions to its requirements in times of peace and war.

To prevent the control of wireless telegraphy by monopolies or trusts, the board deems it essential that any legislation on this subject should place the supervision of it in the Department of Commerce and Labor.

Because international questions may arise, due to the fact that the use of wireless-telegraph stations in our own possessions may affect the use of similar stations in foreign countries, it is desirable for the Congress to enact legislation which will enable the Government properly to handle such cases; a failure to do so may seriously embarrass the Government at some future time.

It is thought that the legislation recommended in placing private stations under the supervision of the Department of Commerce and Labor will also cover this case.

In conclusion, the board deems it essential that the Executive take such action as in his judgment seems wise to prevent the erection of private wireless-telegraph stations where they may interfere with the naval or military operations of the Government until legislation may be had by Congress on this subject.

Appended thereto were two extracts from the Revised Statutes, marked "W" and "X,"[1] which related to the operation of Government telegraph lines; also a decision of the Supreme Court, marked "Y,"[2] and the final protocol of the Preliminary Conference on Wireless Telegraph, held in Berlin in August, 1903, marked "Z."[3]

Navy takes up radio work for the Weather Bureau.—In accordance with the provisions of President Roosevelt's order, the Navy Department immediately began to make arrangements to place its facilities in operation for the handling of Weather Bureau business. Under date of November 30, 1904, orders were issued to its radio stations to promptly transmit all weather reports and warnings required by the Weather Bureau, and also directed its ships equipped with wireless apparatus to take and transmit meteorological observations at least once daily on designated schedule and oftener when barometric changes indicated storm conditions. It has continued to do this work in a satisfactory manner and in an excellent spirit of cooperation.

[1] W and X, section 2, act of Oct. 1, 1890 (26 Stat. 653).
[2] Supreme Court, term of October, 1886. Telegraph Company v. Texas.
[3] Report of Preliminary Conference Concerning Wireless Telegraphy. Berlin, Aug. 13, 1903.

Cooperation with Lighthouse Board.—An immediate development in the use of the naval radio stations was the transmitting of storm warnings to lighthouses and lightships which had radio communication therewith. Cooperation of the Lighthouse Board was secured and arrangements made for the display of storm-warning flags at such lighthouses and lightships. By July 1, 1905, arrangement for radio communication and storm-warning displays at off-shore points had been perfected as follows:

From navy yard, Portsmouth, N. H., to Cape Ann and Thatcher Island, Me.

From torpedo station, Newport, R. I., to Nantucket Shoals Lightship.

From Brooklyn Navy Yard to Highlands of Navesink, N. J.

From Norfolk Navy Yard to Diamond Shoals Lightship.

From Charleston Navy Yard to Charleston Lightship.

From Mare Island Navy Yard to Yuba Buena.

From San Juan Naval Station to Culebra, Panama.

In early succeeding months storm-warning displays were accomplished by the same plan at Cape Elizabeth, Me.; Highland Light; Cape Cod; and Dry Tortugas.

Radio a factor in meteorology.—Radio communication has been an outstanding factor in the developments of meteorology during the past 20 years. It has enabled the Weather Bureau to secure observations from ships at sea and from otherwise inaccessible places, to amplify current synoptic charts used in its forecast work, to reach with its forecasts and warnings places that have no other means of communication, and especially to furnish ships at sea with advices and storm warnings vital to their safety. The functions of the Weather Bureau are such as to require that it keep abreast of radio developments and extensions and to promptly utilize them in every practicable manner.

COLLECTION OF WEATHER DATA BY RADIO.

Weather radiograms from ships at sea.—The first radiogram received by the Weather Bureau containing a weather observation taken on a ship in the Atlantic was from the S. S. *New York*, on December 3, 1905, in latitude 40° N., longitude 60° W. It was the result of arrangements made with the Marconi Telegraph Co. to receive at its station at Siasconset, on Nantucket Island, messages containing weather reports from passenger vessels plying between New York and European ports that were equipped with wireless apparatus. Few reports were received from ships in 1905 and 1906, but sufficient to indicate the great value of and necessity for such observations in forecast work.

In 1906 the vessel weather service was established as a distinct project. The masters of about 50 vessels agreed to take weather observations once daily at a fixed hour when in prescribed ocean areas, and to forward them by radio to the Weather Bureau office in Washington. These vessels were for the most part passenger ships engaged on the New York to Europe routes, although a few operated in the southern Atlantic and in the Gulf of Mexico and one in the Pacific. The latter was the S. S. *President*, which was said to be the only vessel in the Pacific Ocean that carried wireless apparatus at that time. The first observation received from the S. S. *President* was on June 18, 1907. A report from the S. S. *Cartago* on August 26, 1909, when near the coast of Yucatan and at a time that a hurricane was in progress in those waters, was the first ship message that was received and used in connection with the issuance of hurricane warnings.

The vessel weather service was extended in correspondence with the installation of radio apparatus on ships and in a few years included freight as well as passenger vessels. At the present time there are 93 paid vessel weather stations on the Atlantic side and 23 on the Pacific side. Payment of 50 cents is made for each observation taken and radioed. In addition, a much larger number of vessels belonging to ship corporations, who, in recognition of the great benefit the forecasts, storm and hurricane warnings are to them, do not permit any charges to be made by their employees for taking the observations. Among these cooperating companies are the Shipping Board, the Standard Oil Co., the Texas Co., the Gulf Refining Co., Dodwell & Co., Pacific Mail, and the Texas Oil Co.

It is highly desirable that vessel reports be obtained from all areas in the Atlantic and throughout the year, as they are of inestimable value in the forecasting of storms that affect the trans-Atlantic lanes, the southern Atlantic and Gulf of Mexico, but compensation to observers, the cost of radio ship-to-shore tolls, and the inadequacy of appropriations make it necessary to limit the number of vessel weather stations and the period of their operation.

This development of the vessel weather project is indicated by the fact that in 1906, 738 observations were received, and from only 35 ships. In 1922 more than 15,000 reports were received from over 300 ships. All vessel weather observations are transmitted in a special code provided for that purpose.

Nearly all commercial ships engaged in making weather reports are equipped with radio apparatus owned and operated by one of the several commercial radio companies. Under provisions of a law, applicable only to the Weather Bureau, separate contracts are made with these companies and special rates are secured. These contracts provide that, whenever possible to do so, weather messages shall be sent to the nearest naval radio station, which forwards them by land lines to the forecast center to which they are addressed.

Weather observations from ships at sea are of vital importance. They supplement the reports taken at land stations, enable the forecasters to locate storms and hurricanes over the oceans and to issue accurate forecasts and timely warnings to vessels in the storm areas which are not only necessary to safe navigation but are of great aid in the conduct of the ship work at sea.

Cooperation with Shipping Board.—On January 24, 1921, the Shipping Board issued general instructions that beginning with June 1, 1921, all masters of ships under its control should take and forward to the Weather Bureau daily observations when in prescribed areas. Ships in the Atlantic address their messages to Washington; and those in the Pacific to San Francisco and Honolulu, according to their position. No charge is made for the observation work or for radio charges from ship to shore. This cooperation by the Shipping Board is of inestimable value. It is the only group of vessels of commerce on the Atlantic side that radioes its reports throughout the year. The remainder of the vessels operating in the Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea confine their observations to the hurricane season, June to November, inclusive. Ships in the Pacific report throughout the year.

Obtaining observations by radio from otherwise inaccessible places.—As is well known, local conditions are a minor consideration in the making of weather forecasts for a particular section. Dependence is placed mainly on conditions that prevail in more or less extended areas. Therefore, it is necessary for successful forecast work that there be available to the forecaster reports of current conditions from widespread areas. Not until observations from the entire Northern Hemisphere are obtained will the ideal be reached.

For some years after the meteorological service of the United States was established, reports were obtained exclusively by telegraph and mainly from places in the States east of the Great Plains. However, the building of the transcontinental railroad lines soon brought practically all of the States into meteorological range. In succeeding years cable connections with a few islands of the West Indies and of the Pacific, and with Alaska, extended the observation areas. But telegraph lines and cables are placed only in regions where commerce justified their existence, and until the advent of radio there appeared to be no prospect of obtaining current reports from the vast ocean areas, islands, and from the far north, from which observations were so much needed. Radio offered a solution of the problem and the Weather Bureau has availed itself of this form of communication to the fullest possible extent. The observation area has been materially extended thereby, but not nearly to the degree that is hoped for and expected during the years to come.

Countries from which daily reports are received by radio.—Daily or twice daily observations now are secured by telegraph and cable from about 240 stations in the United States and Canada (210 in the United States and 30 in Canada), from 17 places in Mexico, 20 points in the West Indies, 12 Alaskan stations, and 22 European cities. These are supplemented by reports obtained wholly or in part by radio from 16 places in the West Indies and Central America; 5 in Alaska; from Honolulu, Guam, and Midway Island, in the Pacific; the Philippines, China, Japan in the Far East, and from 36 places in Europe and the Arctic regions, including the Azores, Greenland, Iceland, Spitzbergen, and Jan Mayen. All of these radio reports are transmitted by United States naval radio stations, except two in Alaska (Nome and Eagle) for which the United States Signal Corps radio service is utilized. The first Alaskan report obtained by radio was from Nome, on November 1, 1907, followed by Eagle on June 24, 1909; Kodiak and Dutch Harbor, May 1, 1915, and St. Paul Island, August 8, 1915.

The Canadian Government is now arranging for the establishment of radio stations at points in the Mackenzie River region primarily for the purpose of obtaining meteorological reports. These will be made available to the United States Weather Bureau. It is highly important that similar radio and meteorological stations be located in the northern section of Alaska.

It is apparent that meteorology will advance hand in hand with radio and that there must be close and undisturbed contact between the agencies engaged in meteorological and radio activities. The crying need of meteorology is more information from ships and from inaccessible places, and especially from the areas in and about the Polar regions. Meteorology is essentially an international science. Weather has no national allegiance. Cyclones and anticyclones pay no attention to boundary lines. Conditions prevailing in one country to-day may affect another to-morrow, or perhaps a week hence. Partial exchange of meteorological reports between the United States, European, and Asiatic countries has existed for many years, but there must be more or less complete exchange of meteorological reports among the nations in the Northern Hemisphere, and in this radio will play a large and important part.

International exchange of Weather Reports.—The United States is now exchanging weather reports with the meteorological services of Canada, Mexico, Cuba, the Bahamas, Japan, China, the Philippines, the Azores, and France (and through France with other European services). Messages containing reports from 32 stations in the United States and Canada are radioed each night to the director of the meteorological service of France, and are immediately broadcast from the Eiffel Tower radio station for the benefit of all countries within its range.

Radio was first used for transmitting this report to France on January 17, 1919, replacing cable service which had been utilized for many years prior thereto. The forwarding of European reports to the United States began August 15, 1922. These are observations taken in the p. m. and supplement a similar group of a. m. reports forwarded by cable from the London to the Canadian meteorological service at Toronto, which are immediately repeated by telegraph to Washington. A daily message is also received from Paris containing observations taken at midnight at 38 places in Europe, embracing England, Spain, Switzerland, Germany, Austria, Czechoslovakia, Poland, Denmark, Norway, and Sweden; also Iceland, Greenland, and the Azores. Plans are under way for similar exchanges with other countries in which radio will be the communicating medium.

Reports from Nassau, Bahama Islands, have been received in exchange for a group of United States reports for a long period. For more than 20 years they were transmitted by cable, via Jupiter, Fla., but early in 1914 the cable was interrupted and since May 18, 1914, they have been transmitted by radio, first via Key West, later via Miami, Fla., and since November 20, 1922, via Jupiter. In November, 1922, a meteorological station was established at Great Inaugua, one of the Bahama group. A representative of the Weather Bureau was sent there to assist in the installation of instruments and to instruct the observer. The observations are transmitted to Nassau, combined with the Nassau report, and forwarded via the naval radio station at Jupiter and thence by land line to Washington, D. C. The radio station operated by the Bahaman Government at Great Inaugua is not sufficiently powerful to communicate directly with Nassau. Therefore, the reports are relayed through the Cuban radio station at Chaparra. At the request of the Weather Bureau arrangements are being made for the free handling of these reports by the Cuban Government.

Prior to the World War daily observations from a number of points in the Far East, including Siberia, and Russia, were obtained by cable. This service was discontinued during the war, and resumed, with the exception of Siberian and Russian reports, April 9, 1922, when, as a result of arrangements made with the director of the Philippine Weather Service, who collects observations from the Philippine group, China, Japan, and contiguous countries, a daily message is forwarded by naval radio from Manila to San Francisco and thence by land line to Washington. Reports from 12 places are included in this daily message.

Storm-warning work revolutionized.—Before radio communication reached a practicable stage and ships were equipped with radio apparatus the only means of warning vessels of storms was by furnishing masters with the warnings before they left port, and by the display of flags and lights on shore. Such storm signals were visible for a comparatively short distance and ships that departed before the warnings were issued and did not come within visual range of the signals could not be warned. Radio communication has revolutionized the storm-warning service and now ships equipped with the necessary apparatus are as adequately served at sea as when in port.

The first application of radio communication to the storm-warning work was in July, 1902, when the Marconi Co., through its station on Nantucket Island, began to furnish liners of the Cunard Co. with forecasts issued by the Weather Bureau. In 1904, the broadcasting of storm and hurricane warnings became a regular service by naval radio stations and has continued in steadily increasing volume until the present time.

BROADCASTING OF WEATHER BULLETINS.

Inauguration of broadcasting of daily weather bulletins by naval radio stations.—On July 15, 1913, the broadcasting of daily weather bulletins was begun from the naval radio station at Arlington, Va., and Key West, Fla. The bulletins were broadcast at 10 p. m. and in two parts. The first part consisted of code letters and figures showing barometric pressures, wind direction and force at 8 p. m., 75th meridian time, at 8 places on the Atlantic and Gulf coasts and at Bermuda. The second part contained special forecasts of winds along the north, middle, and south Atlantic and the Gulf coasts a hundred miles or so offshore. Storm and hurricane warnings were included whenever issued.

A similar service was inaugurated for the Great Lakes on June 1, 1914, by broadcasts each evening from Arlington during the season of navigation, usually April 15 to December 15, inclusive. Beginning with April 15, 1917, the broadcasts for the Great Lakes were transferred to the naval radio station at Great Lakes, Ill.

At the suggestion of the Navy Department the broadcasting of a special bulletin from the naval radio station at Point Isabel, Tex., was inaugurated on August 27, 1920. This bulletin contains 8 p. m. reports from 8 places on the Gulf coast, also from Jamaica and Swan Island, and forecast and storm and hurricane warnings for the Gulf of Mexico, and the western portion of the Caribbean Sea.

On November 20, 1920, broadcasting of a bulletin for the special benefit of ships in the eastern Caribbean Sea and the southern Atlantic began from the naval radio station at San Juan, P. R. This bulletin is disseminated at 9 p. m., 75th meridian time, only during the hurricane season, June to November, inclusive, and contains reports from 10 observation stations in the West Indies and all hurricane warnings and advices pertaining to the southern Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. And on June 1, 1921, in response to demands from shipping interests the Arlington bulletin was made a twice-daily service, 10.30 a. m. and p. m. The number of coded reports in the a. m. bulletins was increased to 45, and included interior as well as coastal stations. This number of reports and a summary showing the location of cyclone and anticyclone centers and the direction of movement of storms enabled shipmasters to prepare comprehensive weather maps at sea on base maps specially prepared and furnished them for the purpose. An added feature of the expanded Arlington bulletin was upper-air observations from 5 aerological stations operated by the Navy Department, one by the Signal Corps, United States Army, and 3 by the United States Weather Bureau, and, for the special benefit of aviators, upper-air forecasts for 6 zones in which the country east of the Mississippi River is divided. This was the first radio bulletin ever broadcast in the United States for the benefit of aviators, and it was inaugurated at the special request

of the air services of the Army and Navy. On June 26, 1922, the Arlington p. m. major bulletin was made to conform with the one broadcast in the a. m.

On June 10, 1921, a localized broadcasting service was begun on the Atlantic and Gulf coasts and on the Great Lakes to supplement the major bulletins disseminated from the high-powered stations at Arlington, Key West, Point Isabel, San Juan, and Great Lakes. These local bulletins consist of wind and weather forecasts and storm warnings for limited areas, barometer readings, wind velocity and direction, and state of weather at near-by Weather Bureau stations and storm warnings issued in the afternoon. This service was designed for the benefit of coastwise ships not equipped to receive wave lengths as high as those used at the high-powered stations. The naval radio stations utilized in connection with this localized work were Portland, Me.; Boston. Mass.; New York, N. Y.; Philadelphia, Pa.; Baltimore, Md.; Norfolk, Va.; Charleston, S. C.; Savannah, Ga.; Jacksonville, Fla.; St. Augustine, Fla.; Miami, Fla.; St. Petersburg, Fla.; Pensacola, Fla.; New Orleans, La.; Galveston, Tex.; Point Isabel, Tex.; Alpena, Mich.; Buffalo, N. Y.; Cleveland, Ohio; Chicago, Ill.; and Duluth, Minn.; Guantanamo, Cuba; Port au Prince, Haiti; St. Thomas and St. Croix, Virgin Islands. Only hurricane warnings and advices are disseminated from the last five stations. On April 15, 1922, the local service from the stations on the Great Lakes was made twice daily by including an evening broadcast. Broadcasting was discontinued at Jacksonville, Fla., January 21, 1921; at St. Petersburg, Fla., on September 22, 1922; and at Miami, Fla., on November 20, 1922, due to the closing of these radio stations. On December 20, 1922, all the naval radio stations on the Lakes were placed in an inoperative status, and at this time (February 15, 1923) it appears unlikely that they will be placed in service during the 1923 season of navigation.

For the purpose of defining the forecasts contained in the bulletins broadcast from Arlington, Key West, San Juan, and Point Isabel, the ocean areas were divided into the following zones:

1. Atlantic coast, north of Sandy Hook.
2. Atlantic coast, Sandy Hook to Hatteras.
3. Atlantic coast, Hatteras to Florida Straits.
4. East Gulf of Mexico (east of longitude 90°).
5. West Gulf of Mexico (west of longitude 90°).
6. Caribbean Sea (west of longitude 73°) and the Windward Passage.

The forecasts and warnings for zones 1, 2, and 3 are included in the broadcasts from Arlington; zones 3, 4, 5, and 6 in those from Key West; and zones 4, 5, and 6 in those from Point Isabel.

On April 15, 1922, the bulletin broadcast from Great Lakes, Ill., was superseded by a much enlarged bulletin and was made a twice-daily service. It contains observations from 15 stations on the Great Lakes and 12 interior points, as well as upper air observations from 6 aerological stations operated by the Weather Bureau and 1 by the Signal Corps. In addition to weather forecasts for each of the Lakes and flying weather forecasts for four zones are included. These major bulletins are broadcast each morning and evening during the season of navigation on the Great Lakes at 10:45 o'clock, 75th meridian time. At first the bulletins were repeated by the Chicago radio station to Great Lakes for the general broadcast, but on May 19, 1922, the Navy Department began to operate the Great Lakes station by control from Chicago, thereby eliminating the repeat.

On March 15, 1922, a twice-daily major bulletin broadcast was begun from the naval radio station at San Francisco (Goat Island) at noon and 10:30 p. m., 75th meridian time. These broadcasts contain, respectively, 8 a. m. and 8 p. m. coded reports from 6 stations in Alaska, 26 stations on the Pacific coast and in the western States, and five reports from Canada; also upper air observations from five aerological stations, 3 of them operated by the Signal Corps, United States Army; 1 by the United States Navy, and 1 by the Weather Bureau. The several parts of the bulletin consist of a summary of barometric distribution at 8 a. m. and 8 p. m., over the western part of the United States, the Pacific Ocean, Alaska, and Canada, forecasts and storm warnings for the Pacific coast and flying weather forecasts for four zones comprising the Pacific coast States.

On the same date a supplemental localized service for the benefit of coastwise shipping was begun from the naval radio stations at Tatoosh Island, Wash.; North Head, Wash.; Eureka, Calif.; San Pedro, Calif.; and Dutch Harbor, Alaska. These local bulletins consist of wind and weather forecasts and warnings for limited areas, weather conditions, and barometric readings at specified stations, and advices concerning fog conditions in the Strait of San Juan de Fuca. These bulletins are broadcast each morning and evening and at intervals during the day.

Ships in the mid-Pacific forward their observations to the Weather Bureau at Honolulu, and forecasts and storm warnings are broadcast from the naval radio station at that point for the benefit of ships in that section of the Pacific, as well as a report of current weather conditions at Honolulu. These forecasts and reports are broadcast thrice daily. This service was begun on September 11, 1916.

Cooperation with United Fruit Co.—During the hurricane season of 1922 arrangements were made with the United Fruit Co., which for many years has been furnishing weather reports from its ships for broadcasting weather information and forecasts from its radio station on Swan Island for the benefit of shipping in the Caribbean Sea. This service began September 18, 1922. The bulletin is in two parts. The first part is in code and consists of weather observations taken at approximately 8 a. m., 75th meridian time, at Swan Island; Bluefields, Nicaragua; Belize, Honduras; Willemstadt, Curacao; San Juan, P. R.; Port au Prince, Haiti; Cienfuegos, Cuba; La Fe, Cuba; Kingston, Jamaica; and Turks Island, Bahamas. The second part consists of wind and weather forecasts for the Gulf of Mexico, the Caribbean Sea, and the Windward Passage, and all hurricane warnings and advices. The first part of the bulletin is broadcast only in the a. m. during the hurricane season; the second part is disseminated both morning and evening throughout the year. A feature of the service is the display of signals from the radio tower at Swan Island (a red pennant by day and red lantern by night). These signals, which began November 1, 1922, indicate that important weather information issued by the Weather Bureau regarding a hurricane or "norther" is in possession of the radio operator, which can be obtained by radio request or by boat-call ashore. The United Fruit Co. also permits ships of any nationality that fail to obtain the regular weather broadcasts to call the Swan Island station at any time for the latest weather forecasts.

Cooperation with Signal Corps.—The Signal Corps, United States Army, maintains radio stations at Bolling Field (D. C.), Aberdeen Proving Grounds (Md.), Camp Vail (N. J.), Mitchel Field (N. Y.), Langin Field (W. Va.),

McCook Field (Ohio), Langley Field (Va.), Selfridge Field (Mich.), and Chanute Field (Ill.), where weather observations are taken at 6:15 a m., 7:15 a. m., 9 a. m., 11 a. m., and 3:15 p. m., and transmitted by radio for the benefit of aviators using the four model airways—Washington to Long Island, Washington to Dayton, Ohio, Washington to Hampton, Va., and Selfridge Field (near Mount Clemens, Mich.), to Chanute Field (Rantoul, Ill.). All of these observations are collected at Bolling Field and are promptly transmitted by telephone to the Weather Bureau office at Washington and are used by the forecasters in the issuance of flying-weather forecasts and advices to the Army aviators. This cooperative service began October 16, 1922.

RADIO WEATHER SERVICE FOR MARINE AND AGRICULTURAL INTERESTS.

Weather service for ships in midocean.—The need for and value of a forecasting service for the benefit of ships in midocean, and especially along the routes between the United States and Europe, long has been recognized, but there have been inherent difficulties which prevented the inauguration of a service of this character, chiefly the impracticability of collecting promptly and accurately current observations essential to such a system. For many years the Weather Bureau has been issuing twice-daily forecasts of wind and weather as far as the Grand Banks for the benefit of ships leaving North Atlantic ports, but it is apparent that a forecasting service for ships in midocean can not be conducted from any station located on continental shores and no island in the American-European lanes has a location advantageous to the purpose. The ideal arrangements would be one or more "floating islands"—ships anchored at selected positions—with trained meteorologists and forecasters aboard, to serve as collecting stations where weather reports would be charted and forecasts disseminated on fixed schedules. This is not possible of realization in the near future.

The most practical solution of the problem at the present time is the use of ships traveling the lanes with more or less regularity. The practicability of such a scheme already has been demonstrated by the French training ship *Jacques Cartier*. This ship has among its corps of instructors experienced meteorologists and forecasters, and on each of its voyages daily weather charts are prepared from weather reports furnished by ships within call and the weather reports and bulletins broadcast from the Arlington naval radio station and the Eiffel Tower. The forecasts are broadcast from the *Jacques Cartier* on regular daily schedules in both English and French.

The United States Weather Bureau is deeply interested in this pioneer project and is cooperating in the work. Maj. E. H. Bowie, the supervising forecaster of the Weather Bureau, took passage on the *Jacques Cartier* on its return voyage to France on February 11, 1923, for the purpose of assisting in the forecast work and observing the working of the scheme, especially in connection with the collection of observations by radio, and with the ultimate object of developing a program of service on American ships.

The dissemination by the Weather Bureau of weather information, forecasts, storm and hurricane warnings for the benefit of marine interests is believed to be the most complete and effective in the world. This valuable and indispensable service is accomplished in major part through radio stations operated by the Navy Department, and the Weather Bureau is greatly indebted to the officers connected with its radio operations for their cordial and sympathetic cooperation in this work.

Weather maps at sea.—The first weather map prepared at sea of which the Weather Bureau has a record was aboard the Red D Line S. S. *Caracas*, on December 1, 1905. The map was made by Mr. B. C. Kadel, an official of the Weather Bureau, when on his way from Willemstadt, Curacao, to New York. When off Cape Hatteras the weather was thick and the sea rough. The wireless operator, at the request of Mr. Kadel, obtained reports of barometric readings, state of weather, and wind direction and force from a number of ships and from a radio station on the Jersey coast and another at Hatteras. These reports were charted, and an accurate forecast was made that the *Caracas* would be out of the storm area by morning.

In August, 1908, Dr. P. Polis, director of the meteorological observatory at Aachen, Germany, made weather maps every day on board the S. S. *Kaiserin Augusta Victoria* during a passage from Germany to the United States. The reports were obtained by radio from United States coastal stations, from Europe, and from other ships.

The preparation of weather maps on ships is now common practice. The Weather Bureau furnishes masters special base maps for the purpose and the data are obtained from weather bulletins which it issues and broadcasts through naval radio stations. By means of the weather map storm centers are located and charted, and they provide a valuable aid in navigation.

Serving agriculturists by radio.—The act of Congress creating the Weather Bureau contains the expression, "for the benefit of *agriculture*, commerce, and navigation." Until recent years it was not possible to extend the benefits of the service effectively to agricultural interests, because a large proportion of the farmers could not be promptly supplied with weather forecasts and warnings of cold waves, heavy snows, frosts, etc., by ordinary means of dissemination. Extension of telephone lines into rural communities overcame a part of this difficulty, but large numbers of them could not be served thereby.

The Weather Bureau recognized the possibilities of radio in reaching agricultural interests and it began the dissemination of forecasts by this means as early as 1914. In January of that year arrangements were made for the broadcasting of forecasts by a station operated by the University of North Dakota, and nine amateur operators in that State received the forecasts in this way and made local distribution of them. In June, 1915, similar arrangements were made at Illiopolis, Ill.; Rock Island, Ill.; and Springfield, Ill. Sixteen amateurs, owning receiving sets, were known to obtain and distribute the forecasts.

On February 15, 1921, broadcasts of forecasts by radio stations operated by the Post Office Department in connection with its air mail service at Omaha, Nebr., and North Platte, Nebr., were begun, and a little later from its stations at Washington, D. C.; Bellefonte, Pa.; St. Louis, Mo.; Cheyenne, Wyo.; Rock Springs, Wyo.; and Salt Lake City, Utah. The service from St. Louis and Bellefonte was in operation only a few months.

The distribution of forecasts by radiotelegraphy to interior points served a valuable purpose, but it was of limited use to farmers, because few of them could take the time required to learn the telegraph code, and on that account they did not feel justified in installing receiving apparatus. However, the marvelous developments in radiotelephony during the past year or two changed the situation, and the Weather Bureau has kept abreast of these developments.

Broadcasting twice daily, at 10 a. m. and p. m., by radiotelegraph from the Arlington naval radio station of weather forecasts for each of the States comprised in the Washington forecast district, and on Wednesdays (April to October, inclusive) a summary of weather conditions as they affected crops during the preceding week, was inaugurated June 26, 1922. Similar services for the States in the Chicago, San Francisco, and New Orleans districts were begun June 20, 1922, August 23, 1922, and January 1, 1923, respectively.

Radiophone weather broadcasts.—The first systematic radiophone broadcasts of forecasts were made from the station operated by the University of Wisconsin beginning with January 3, 1921. Prior to that date and since October 1, 1916, broadcasts had been made therefrom by radiotelegraph. The next radiophone forecast distribution service was inaugurated on April 26, 1921, by the St. Louis (Mo.) University. This was the first station to disseminate river forecasts by this means.

On July 1, 1921, 12 radiophone stations in 7 States were broadcasting weather information, daily forecasts, river forecasts, crop information, cold-wave, frost, and other warnings. Since that time the work has been rapidly extended, and at the present time 140 radiotelephone stations in 39 States are engaged, as follows:

Alabama	3	Nebraska	7
Arkansas	1	New Jersey	1
California	11	New Mexico	3
Colorado	2	New York	8
District of Columbia	1	North Carolina	2
Florida	1	North Dakota	2
Georgia	3	Ohio	7
Territory of Hawaii	1	Oklahoma	3
Idaho	1	Oregon	3
Illinois	4	Pennsylvania	6
Indiana	3	Rhode Island	2
Iowa	6	South Carolina	1
Kansas	6	South Dakota	2
Kentucky	1	Tennessee	1
Maryland	1	Texas	13
Massachusetts	2	Utah	3
Michigan	3	Washington	2
Minnesota	6	Wisconsin	4
Missouri	8	Wyoming	3
Montana	3		

Practically all of the State forecast radio distribution work is conducted in cooperation with plants owned by individuals and commercial organizations, and at very little expense to the Weather Bureau. The forecasts and warnings are supplied them, as a rule, by telephone from field stations.

No broadcasting of weather reports and forecasts by radiophone were made by the Navy Department until February 15, 1923, on which date such service began from the Arlington station on 710 meters wave length. This service consists of the broadcasting, twice daily, at between 10:05 and 10:20 a. m. and p. m., of the forecasts for each of the States comprised in the Washington forecast district (all States east of the Mississippi River except Michigan, Illinois, and Indiana) and a general forecast for the district. Special warnings of cold waves, frosts, heavy snows, etc., issued in the afternoon and not included in the regular morning and evening broadcast, are disseminated between 3:45 and 4 p. m. Distant control operation is a feature of this service. The Weather Bureau office is connected by telephone with the radio operating room of the Navy Department, and the forecasts are announced from the forecast room of the Weather Bureau.

At a meeting of the Inter-departmental Advisory Committee on Governmental Radio Broadcasting held on February 2, 1923, it was decided to transfer all broadcasting bone dy the Post Office Department for the Department of Agriculture, including the Weather Bureau, to the Navy Department. The Arlington radiophone service was inaugurated in accordance with this program. This affects the service performed by the Post Office radio stations at Washington, D. C.; Omaha, Nebr.; North Platte, Nebr.; Rock Springs, Wyo.; and Salt Lake City, Utah, and broadcasts of weather reports and forecasts from Washington were discontinued February 15, and from the other stations of the Post Office Department on March 1, 1923.

WEATHER BUREAU REPRESENTATION ON INTERNATIONAL AND OTHER RADIO BOARDS.

An international conference on wireless telegraphy was held in Berlin, June 28, 1906, on invitation extended by the German Government. The then Chief of the Weather Bureau, Prof. Willis L. Moore, was designated as the representative of the Department of Agriculture, but he was unable to attend. The transmission of meteorological observations evidently was not a serious subject of discussion and was not mentioned in the articles of agreement.

Professor Moore also represented the Department of Agriculture in the International Radio Telegraph Conference which was held in London during June and July, 1912. He attended the meetings and was signatory to the articles of that convention, which are now in effect. Meteorological observations and their transmission by coastal stations entered largely into the discussions, and Professor Moore took an active part in the formulation of Article XLV, which pertains to that feature of radio work.

In 1914 a committee of representatives of the several departments was appointed to draft regulations for radio telegraphy. Prof. A. J. Henry, of the Weather Bureau, was designated and served as the representative of the Department of Agriculture.

On October 21, 1915, an inter-departmental committee on radio legislation was formed. Prof. C. F. Marvin, Chief of the Weather Bureau, was appointed to represent the Department of Agriculture. This committee drafted a bill to regulate radio communication, which was introduced in the House of Representatives on December 22, 1916 (H. R. 19350) and in the Senate on December 19, 1916 (S. 7478).

On September 14, 1920, the American delegates to the preliminary conference on communication, to be held in Washington on October 8, 1920, invited Prof. C. F. Marvin to meet with them prior to the convocation of the conference for the purpose of discussing the subjects to be considered by the delegates to the radio protocol. The discussions of most interest to the Weather Bureau related to arrangements for the international exchange of meteorological reports by radio, and resulted in specific recommendations relating to collection of reports over extended areas by particular nations, who should become responsible for their redistribution to other cooperating nations; also to the procurement of a much greater number of meteorological reports from ships at sea. However, the delegates were disposed to regard these matters as foreign to the real purposes of the convention, and no action thereon was taken.

Early in 1921 the Secretary of State created an interdepartmental board to consider questions concerning communication, especially with reference to radio and telegraphic service for the Government. On May 17, 1921, Secretary Wallace nominated Professor Marvin as the representative of the Department of Agriculture.

METEOROLOGICAL STATIONS IN HIGH LATITUDES.[1]

By SIR FREDERICK STUPART, Director, Meteorological Service of Canada.

[Meteorological Office, Toronto, Canada, February 23, 1923.]

As the years go by, the public, in the many countries which maintain meteorological services, become more and more convinced of the necessity of an increased knowledge of the climatology of land and sea and also of the usefulness of weather forecasts, but even now governments which control national expenditure appear loth to supply the funds for special investigation, the expediency of which is obvious to the scientific worker.

Our legislators do certainly regard with favor the efforts of the meteorologist to supply data recognized as important in furthering the successful accomplishment of many activities in commerce and finance. They readily allow that a knowledge of the weather prevailing along trade routes is useful and that accurate weather forecasts for the coasting shipping is desirable. Also the data demands by engineers covering rainfall and snow over watersheds to be utilized either for irrigation or for electrical power is recognized as being indispensable.

When, however, it comes to granting funds for the equipment of an out-of-the-way Arctic station—or a lonely island station, the benefits to be derived are not quite obvious and difficulties may arise.

It is certain, moreover, that in order to have a full understanding of the atmospheric circulation data must be received from all portions of the globe. There is no other science in which the problems to be solved requires more international cooperation than does meteorology which deals with the atmosphere and its circulation. The initial stages in the development of a storm which may devastate a portion of the United States coast may have occurred in Canada and vice versa, and the successful warning of many a disastrous hurricane in the south has been from information received from Mexico and the West Indies.

In early days of the synoptic weather map, the data on which forecasts were based was very meager compared with that which we possess to-day. In looking over the early charts showing storm tracks it is interesting to note how fallacious were our ideas as to the real location of the tracks of depressions; many were shown as being near the fiftieth parallel, whereas the centers were in reality much farther north, and during the colder months were probably the offspring of deep barometric depressions off the northern coasts of Alaska. Then again, there was always doubt regarding the approach of anticyclones from the Northwest and it was not until the Northwest States and Manitoba were in the grip of the blizzard that warning of cold waves could be dispatched to the region of the Great Lakes.

Forecasts were not issued by the Canadian Service until October, 1876, and for several years Winnipeg was the most outlying telegraph-reporting station in the Northwest; it was several years later that Qu' Appelle, Battleford, Calgary, and Edmonton, became reporting stations, and it was not until 1890 that we had reports from British Columbia. During all these early years the Canadian Service, and I doubt not the American Weather Bureau, quite realized how much they were handicapped by the lack of data from the North, and many years were to pass before there was any marked improvement. Canada opened a telegraph station at Dawson City, Yukon Territory, in 1900, but the telegraph line was more often down than up and being so far distant from other stations, its usefulness was not equal to what it is to-day.

That meteorologists were of the opinion that a knowledge of pressure distribution in high latitudes is essential to a fuller understanding of atmospheric circulation is certain from the numerous discussions at the various meteorological conferences which were doubtless an important factor leading to the establishment of stations in Iceland and Spitzbergen and quite recently Jan Mayen Island.

In my opinion one of the greatest advances made in the weather map from the point of view of research workers in the United States and Canada occurred when, in 1912, the Alaskan stations began to transmit their reports to Washington. This was a splendid contribution.

About the same date also European reports were first received regularly in both Washington and Toronto, but unfortunately just as we were beginning to thoroughly appreciate their value, the war broke out and it was not until April, 1921, that they were resumed.

I am glad to be able to state that during the next summer Canada will place several wireless stations in the valley of the Mackenzie River, which will we trust afford valuable data supplementary to that received from Alaska, regarding the development of anticyclonic areas and cold waves.

It seems a far cry from Alaska to Great Britain and northwestern Europe but by great circle across the polar regions the distance after all is not so very great, and when we enter the barometric readings of Europe, Spitzbergen, Iceland, and Jan Mayen Island on a meteorological chart of polar projection and enter on the same chart the Alaska readings, together with the reports from regular American-Canadian weather chart it is usually possible to interpolate for the polar regions and connect and join up the isobars of northern Europe with those of northern America. Charts thus prepared show us a great deal and would appear to indicate that the general character of the winters of the Northwestern States and northwestern Canada and even of the Great Lakes depends very largely on the meteorological conditions over the North Pacific Ocean and Alaska. We know that during the winter months radiation over the wide land areas of Siberia and northern America leads to the formation of high pressure and intense cold. These maps make it clear, however, that in some winters at least, the North Pacific LOW plays a rôle which tends greatly to modify the pressure distribution in northern America. In these winters deep depressions come in over the Aleutian Islands and northern Alaska and seem actually to prevent the formation of anticyclones over the Mackenzie River Valley, and when this occurs mild winters may be looked for throughout northwestern America and even to the Great Lakes.

In other winters the North Pacific LOWS either lack energy or approach the American coast much farther south and then anticyclonic conditions take control in the north and great cold waves sweep southeastward over the continent. In such winters it would almost seem that the Siberian high pressures extended across as one system into America.

A study of these northwestern America early winter types of pressure distributions is exceedingly interesting, and it appears to me that there is perhaps no part of the

[1] Presidential address given before the American Meteorological Society, at Boston, Mass., Dec. 30, 1922.

continent where meteorological conditions can be more profitably studied, leading as they do to such far-reaching results.

It happens that within the past five years there have been marked examples of extreme types of both dominant anticyclonic and cyclonic conditions in these high latitudes. In December, 1917, the anticyclone was dominant in northwestern America. In December, 1918, it was the cyclone which dominated and southerly and southwesterly winds prevailed through the Canadian and American west even to the Great Lakes.

In view of the facts I have outlined, it appears to me to be desirable that the number of stations in the Arctic Zone should be augmented. The existing Alaskan stations are admirably situated, but another station at Point Barrow would be a great acquisition. A few stations in northeastern Siberia would be most instructive and one hopes that their establishment will not be long delayed. Canada, as before stated, will this coming summer place wireless stations at a few points in the valley of the Mackenzie River and one hopes that a couple of stations in Baffin land will be in existence within a year or so. The North American stations will then link up well with the Danish and Norwegian stations of Greenland, Jan Mayen, Spitzbergen, and others, thus affording splendid data for investigating changes in the polar front.

While advocating an increase in the number of meteorological stations in high latitudes, I am not unmindful of the fact that a meteorological survey of the Pacific Ocean with its varying currents and temperatures may be even more important than a land survey, as the variation in the intensity of Pacific cyclones may depend largely on variations in ocean temperatures.

Assuming now that the great importance of stations in the far northwestern portions of North America has been demonstrated, we might with perhaps equal certainty show that wireless stations on Hudson Bay and in Baffin land would be most useful. When great anticyclones come in over western America their dominating influence is usually lessening as they spread toward the Atlantic coast, and we find that some of the coldest waves in eastern Canada accompany high areas coming in over Labrador, which high areas develop over the northeastern, not the northwestern, portion of the continent; and again these Hudson Bay and Labrador high areas represent the conditions under which Atlantic coast depressions are apt to develop, and moving northeast give severe storms along the Atlantic steamship routes.

FREQUENCY DISTRIBUTIONS OF DAILY AND HOURLY AMOUNTS OF RAINFALL AT GALVESTON, TEX.

By I. R. TANNEHILL, Meteorologist.

[Weather Bureau, Galveston, Tex., December 15, 1922.]

The rapidly-increasing use of rain insurance invites attention to the frequency distribution of rainfall. There has been considerable discussion of this subject in recent years and little hope is offered for a mathematical solution. Frequency polygons and other graphical solutions have been presented and these are valuable in that they disclose certain peculiarities in the frequency distribution of rainfall, perhaps local, which must be taken into account in any complete description of the climate and which would otherwise escape attention.

One of these peculiarities is the skewness or assymmetry of rainfall distributions.[1] The study of a series of rainfall-frequency polygons shows that the distribution of annual amounts does not conform to the law of errors;[2] that negative departures occur somewhat more frequently than positive and that the amount occurring with the greatest frequency is less than the mean. In consideration of monthly amounts it is found that the distribution is less symmetrical and may be multimodal.[3] The frequency distribution of daily amounts bears no resemblance to the normal or Gaussian distribution of errors. It is best represented by a J-shaped curve.

Thus, we find that shortening the period of time in which the individual amounts fall apparently increases the skewness or asymmetry of the distribution.

Therefore the problem that confronts the insurance company in the establishment of rates for rain insurance is the most difficult, since hourly and daily amounts are insured against and chiefly the former.

We may obtain an average value of rain frequency for either the day or the hour in any given locality. In the long run these averages will be borne out approximately. Rain insurance is not issued for all hours of the day and night with the same frequency, nor for all seasons with the same frequency, and therefore the averages or means are not trustworthy.

Again, all amounts of rain are not insured against. The policies usually limit the amounts to 0.10 inch or more, or to 0.20 inch or more. Another artificial limit has been introduced which greatly complicates the problem.

In preparing a table of premium rates for rain insurance the insurer depends upon the records of the Weather Bureau. Rain data are usually in the form of means and totals together with rather limited information concerning the frequency of certain extremes or excessive amounts. Because of the fact that the distributions of rain frequency are unsymmetrical in monthly and annual amounts and altogether asymmetrical in daily and hourly amounts, these means are of doubtful value in determining the probability of occurrence of certain amounts.

For example, the Weather Bureau computes a normal fall of rain for each day in the year. This amount may be, say, 0.12 inch for January 1 in a given locality. This value, 0.12 inch, is of no particular value in determining the probability of rain on January 1. At Galveston the normal for January 1 is 0.15 inch. In the 50 years this station has been in operation, the amount 0.15 inch has never occurred on January 1.

It would be possible to compute a normal fall for each hour of the year. Such a value would have no particular use. How, then, is the insurer to arrive at any trustworthy conclusion as to the amount or amounts likely to occur with the greatest frequency and how is he to determine the frequency with which a certain amount will be exceeded?

Rate tables have been issued, however, and one company states that rain insurance is being written almost as freely as fire insurance. Apparently these rates are based upon the frequency of days with 0.01 inch or more of precipitation.

In the following, the frequency of daily and hourly amounts of precipitation will be discussed with reference to Galveston, Tex., in the attempt to show that the aver-

[1] Tolley, Howard Ross: Frequency Curves of Climatic Data; Mo. WEATHER REV., November, 1916, 44: 634-642.
[2] Marvin, Charles Frederick: Elementary Notes on Least Squares, the Theory of Statistics and Correlation for Meteorology and Agriculture, Mo. WEATHER REV., October, 1916, 44: 551-569.
[3] Weeks, John R.: Climate of Binghamton, N. Y., shown by the Histogram Method; Mo. WEATHER REV., February, 1921, 49: 53-62.

age frequency of any amount is not a reliable basis for determination of such rates and that the insurer must take into consideration at least three facts: (1) That the frequency distribution of daily and hourly amounts is asymmetrical and that the mean is therefore not altogether trustworthy; (2) that mean rain intensity varies with time and place and therefore the frequency of any given amount of rainfall is not a reliable indication of the frequency of any other amount; (3) that rain frequency exhibits a decided daily march at Galveston and other places and that the maximum frequency may be five times or more in excess of the minimum.

In the REVIEW for February, 1921, will be found the frequency distributions of monthly rainfall at Binghamton, N. Y.[3] These histograms are characteristic of daily rainfall. The frequency curve best fitting these data has been described as of the J-shape, though the curve which fits the frequency distribution of various percentages of cloudiness is more nearly the J-shape.

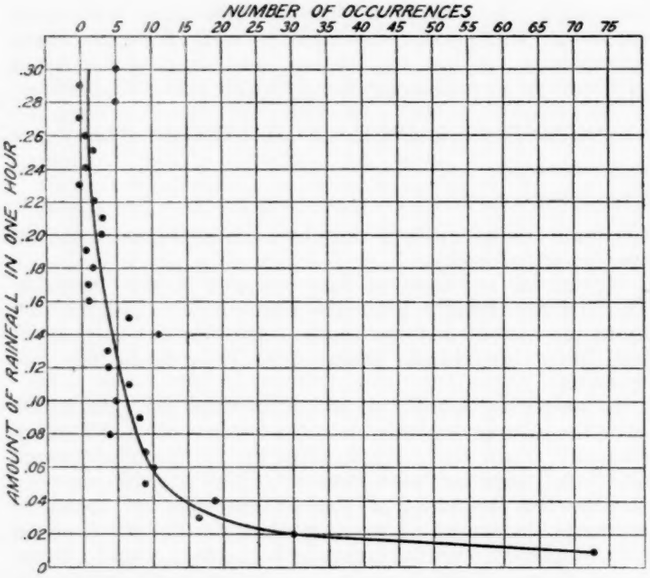

FIG. 1.—Frequency distribution of hourly amounts of rainfall at Galveston, Tex., during the year 1921. Mean of measurable hourly amounts was 0.14 inch. Curve fitted approximately.

In Figure 1 is shown the frequency distribution of hourly amounts of rainfall at Galveston, Tex., during the year 1921. Though this is a short period used in the grouping, the distribution approximates the form of the daily distribution. In this figure a total of 244 values were grouped up to and including 0.30 inch. The mean of all hourly falls, totaling 285, is 0.14 inch. There were 11 departures equal to the mean, or with a departure of zero. Only 26 per cent of all departures were positive. This distribution does not include the number of occurrences of a "trace" of rainfall nor of hours with no rain, the latter two classes totaling more than 8,000.

It is apparent that the mean hourly or mean daily rainfall is of no value in determining the probability of rainfall on any particular day or in any stated hour.

Table 1 shows the average number of days in a month at Galveston, Tex., with 0.01 inch or more, 0.04 inch or more, 0.25 inch or more, and 1 inch or more, for summer and winter months, roughly. This covers the 50-year period of observation at Galveston.

[3] Weeks, John R.: Climate of Binghamton, N. Y., shown by the Histogram Method; Mo. WEATHER REV. February, 1921, 49: 53-62.

TABLE 1.

Month.	Average number of days with—			
	0.01 inch or more.	0.04 inch or more.	0.25 inch or more.	1 inch or more.
June, July, August, and September	8.7	7.0	3.7	1.3
November, December, January, February, and March	9.2	6.6	3.1	1.0

It will be noticed that there is a greater frequency of days with 0.01 inch or more in November to March, inclusive, but that the summer months show a greater frequency of the larger amounts. Therefore insurance rates based on the number of days with rainfall 0.01 inch or more for the several months will be in error because of the greater average rain intensity at some seasons than others.

One insurance company now makes a rate for insurance against amounts of 0.20 inch or more at Galveston in the month of November $4.98 per $100 and in February $5.53 per $100. This is evidently based on frequency of days with 0.01 inch or more rainfall.

Yet the 50-year record at Galveston indicates that, though 0.01 inch or more fell on 398 days in November and 467 days in February, there were only 133 days with 0.25 inch or more in February against 165 days in November. That this is the case is indicated in Table 1, showing that it is not fortuitous but is a characteristic of the season. The average rain intensity in November is greater than in February.

Thus we can not accept the average daily or average hourly fall as a criterion. Such averages are practically worthless because of the asymmetry of daily and hourly rainfall distributions. Information as to the frequency of certain amounts is required.

Though we have tabulated the frequency of days with 0.01 inch or more, 0.04 inch or more, 0.25 inch or more, and 1 inch or more, these data are insufficient. The frequency of any one of these amounts is not a reliable indication of the frequency of any other amount. If we are concerned with the frequency of hourly or daily falls of 0.10 inch or 0.20 inch we must determine these facts directly and not by assumption.

Figure 2 shows the frequency of amounts of 0.01 inch or more at Galveston, Tex., for each hour during the months June, July, August, and September in the 10 years 1913 to 1922, inclusive. There is a very pronounced daily march of rain frequency. The horizontal line at frequency of 44 represents the average of hourly frequencies. It will be seen that rain frequency at hours usually named in policies is considerably less than the average and therefore considerably less than would be indicated by consideration of the average number of days with 0.01 or more.

The causes of this variation of rain frequency were explained in the MONTHLY WEATHER REVIEW for September,[4] 1921, where a similar daily march of rain frequency at Corpus Christi was discussed. There it was shown that the daily rise of the sea breeze about noon is sufficient to suppress convection. The mean hourly wind movements at Galveston are also shown in Figure 2, indicating that the reduction in rain frequency in the afternoon is due to increased wind movement. Attention is invited to the fact that both at Galveston and

[4] Tannehill, I. R.: Wind Velocity and Rain Frequency on the South Texas Coast; MO. WEATHER REV., September, 1921, 49: 498-499.

Corpus Christi the frequency of rain begins to decrease when the wind movement has reached a value approximately 12 to 13 miles per hour.

Figure 3 shows the daily march of rain frequency during the months of November, December, January, February, and March. Occurrences of 0.01 inch or more in those months during 10 years, November, 1912, to March, 1922, inclusive, were tabulated by hours. It will be noticed that there is a rather poorly defined daily march with the maximum frequency about 9 a. m. The average hourly frequency of 66 for that period is shown by the horizontal heavy line. During the early evening there are slightly lower rain frequencies than the average.

Thus it will be seen that the average number of days with 0.01 inch or more gives no indication of the relative frequencies of hourly amounts in summer months in the afternoon and early evening, for which hours rain insurance is usually issued.

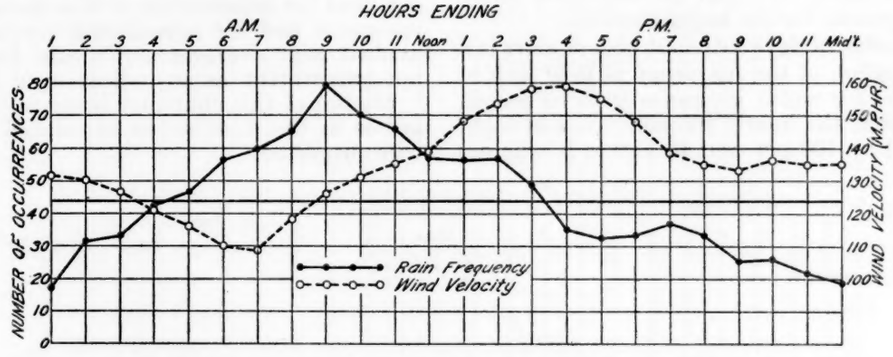
HOURS ENDING
A.M.
P.M.
1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Mid't.
NUMBER OF OCCURRENCES
WIND VELOCITY (M.P.H.R.)
Rain Frequency
Wind Velocity

FIG. 2.—Mean hourly wind velocity, Galveston, Tex., June, July, August, and September, 1913-1922, inclusive, and number of occurrences of rain, 0.01 inch or more, June, July, August, and September, 1913-1922, inclusive.

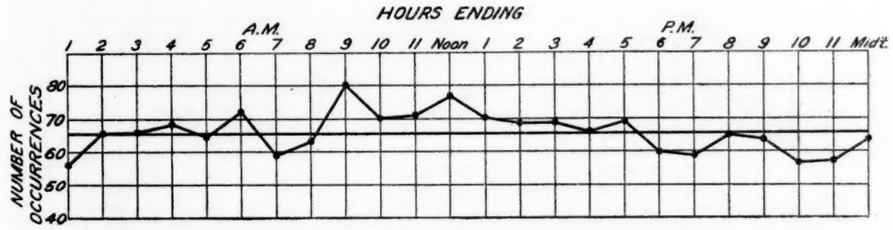

FIG. 3.—Hourly frequencies of 0.01 inch or more rainfall in months of November, December, January, February, and March, for 10-year period, November, 1912, to March, 1922.

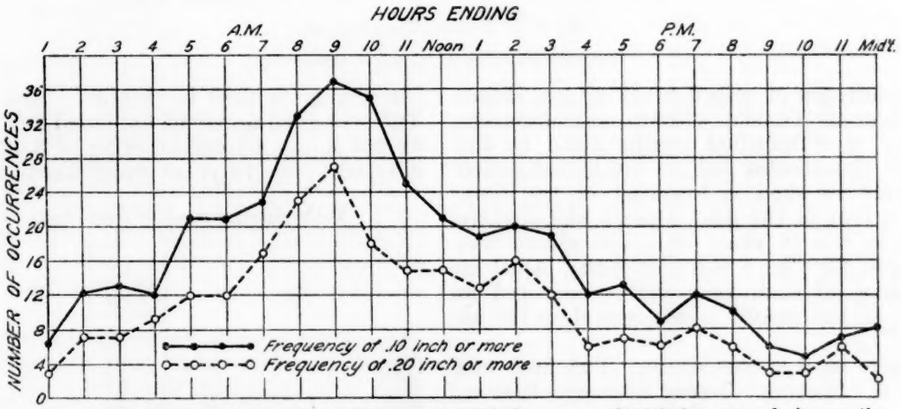
HOURS ENDING
A.M.
P.M.
1 2 3 4 5 6 7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Mid't.
NUMBER OF OCCURRENCES
Frequency of .10 inch or more
Frequency of .20 inch or more

FIG. 4.—Number of occurrences of rainfall of amounts 0.10 inch or more, and 0.20 inch or more, during months of June, July, August, and September, from 1913 to 1922, inclusive.

The error in this assumption is, however, somewhat more aggravated than these figures would indicate. The amounts insured against are usually 0.10 inch or 0.20 inch. Figure 4 shows the hourly march of rain frequency during months of June, July, August, and September for the years 1913 to 1922, inclusive, and the values charted were 0.10 and 0.20 inch or more. It will be seen that the march of hourly frequencies of 0.10 inch

or more and 0.20 inch or more is even more pronounced than that of 0.01 inch or more.

To illustrate this point, see Figure 5. The mean frequencies for the day for each amount, 0.01 inch, 0.10 inch, and 0.20 inch are shown as 100 per cent, and the hourly frequencies are shown in percentage of the average. By this means it is easily seen that the amplitude of the daily variation is greater for the larger amounts.

If we use the number of days with 0.01 inch or more in a month as an indication of the frequency of 0.20 inch or more in any period for which insurance is to be issued, we are assuming that the hourly frequency is a straight line as represented by 100 per cent in Figure 5, whereas the frequencies at 9 a. m. and 9 p. m. differ by more than 200 per cent.

In conclusion, it is evident that we can determine the frequency of any given amount in any stated period in only one way and that is by considering the individual occurrences of that amount in the stated period and grouping these values about a mean. There is a growing need for information of this character, both for rain insurance and for agricultural purposes. It is clearly evident that averages and means for rainfall data are not trustworthy as an indication of future occurrences.

Studies of this character bring to light certain peculiarities in the distribution of rainfall locally, not otherwise suspected.

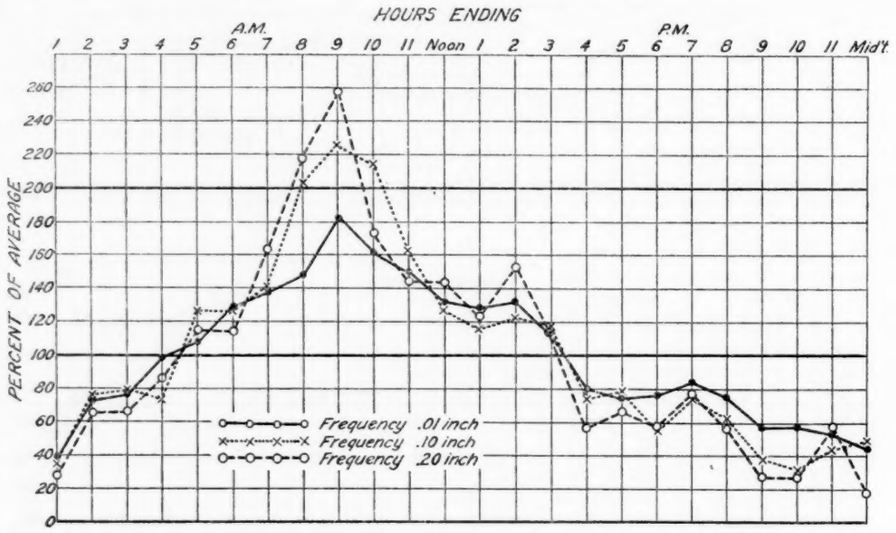

FIG. 5.—Hourly frequencies of 0.01 inch, 0.10 inch, and 0.20 inch, expressed as percentage of the average hourly frequency.

LOWERING OF KANSAS RIVER CHANNEL AT TOPEKA, KANS.

By S. D. FLORA, Meteorologist.

[Weather Bureau, Topeka, Kans., October 12, 1922.]

The frequent occurrence of record-breaking low stages in the Kansas River at Topeka without any apparent cause in the way of diminished precipitation in the drainage basin of the stream led to an investigation which seems clearly to show a lowering of the river channel of about a foot in the past 5 years and slightly more than 3 feet in the 18 years since the record was begun. Only stages for the 6 warm months, April to September, inclusive, of each year were considered in the investigation, as the record is not complete for all winter months.

Two methods were used in this study. The first was the utilization of a "floating" 5-year average—that is, by obtaining the average stages for successive 5-year periods from the beginning of the record and plotting them. (See fig. 1.) The second was the construction of a trend from a formula in use by statisticians, which has the advantage of making it possible to plot the change from the first year of the record to the last. (See fig. 2.) The graph representing this trend was obtained by means of the accompanying table.

It is interesting to note that the two methods corroborate each other closely. Figure 1 shows a lowering of the stage of 1.2 feet in the last 5 years of the record and Figure 2 a lowering of 0.95 feet, while from 1909—the first year for which a 5-year mean is available—to 1922 the change is 2.80 by Figure 1 and 2.66 by Figure 2. The straight-line trend extended to the first year of the record shows a total lowering of 3.42 feet in the stream channel in the 18 years under discussion.

Table showing trend of river stages at Topeka, Kans.

A. Year.	B. Average gauge height.	C.	D.	E.	F.
1905	9.5	−17	−161.5	289	8.76
1906	7.6	−15	−114.0	225	8.57
1907	6.7	−13	−87.1	169	8.38
1908	10.4	−11	−114.4	121	8.19
1909	8.4	−9	−75.6	81	8.00
1910	7.8	−7	−54.6	49	7.81
1911	6.4	−5	−32.0	25	7.62
1912	7.0	−3	−21.0	9	7.43
1913	5.3	−1	−5.3	1	7.24
1914	5.5	1	5.5	1	6.86
1915	11.1	3	33.3	9	6.67
1916	6.9	5	34.5	25	6.48
1917	5.8	7	40.6	49	6.29
1918	4.9	9	44.1	81	6.10
1919	7.5	11	82.5	121	5.91
1920	5.7	13	74.1	169	5.72
1921	5.5	15	82.5	225	5.53
1922	4.9	17	83.3	289	5.34
Sum	126.9		−185.1	1,938	
Average	7.05				

1938÷2=969.
−185.1÷969=−.19=yearly change trend.

EXPLANATION OF THE TABLE.

A is the year to which the data apply.

B is the average gauge height for the 6 months, April to September, inclusive.

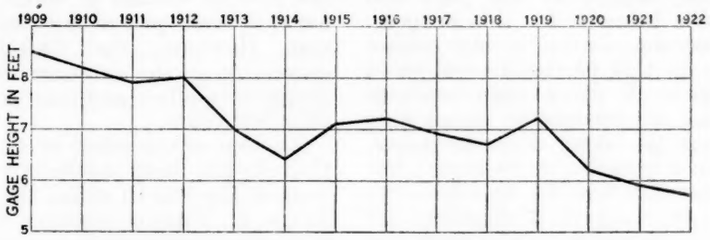

FIG. 1.—Trend of 5-year averages of river gauge readings at Topeka, Kans., for the summer months, April to September, inclusive. The value for each year is the average stage of the five years immediately preceding.

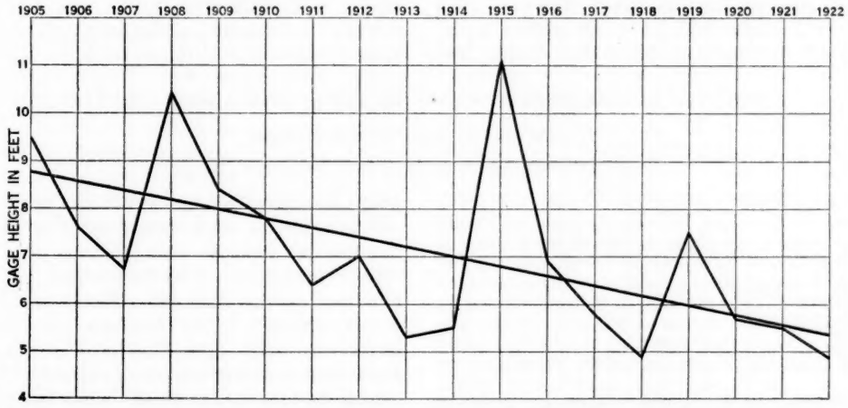

FIG. 2.—Trend of river stages at Topeka, Kans. The broken line indicates the trend of average stages for the 6-month period April to September, inclusive, of each year from the beginning of the record. The straight line is the trend, obtained mathematically.

C is the number of years distant from the middle of the record, multiplied by 2 for convenience in further computations.

D is the product of B × C.

E is the square of C.

F is the adjusted trend, obtained as follows: The average stage of the series, 7.05, is put as the mean trend stage at the middle of the series. The quotient of the sum of the column headed D divided by one half the sum of the column headed E ($-185.1 \div 969$, or $-.19$) is made the yearly change or trend from the mean trend stage, which is 7.05. The trend is obtained by subtracting the trend change, $-.19$ from 7.05 once for each successive year prior to the middle of the series and adding it once for each successive year subsequent to that point.

That this decrease in the average gage height has not been attended by a corresponding deficit in stream flow is shown by a study of the rating curves that give discharge in second-feet for the past five years, prepared by the United States Geological Survey.

The rating curve for 1917, the first year for which discharge measurements were made, and that for 1922 are given in Figure 3. No stages lower than 3.5 feet occurred in 1917, hence it was not possible to extend the curve for that year as low as the one for 1922, when a stream-flow measurement was made at a stage of less than 2.5 feet. However, the curves show that at a stage of 2.5 feet in 1922 the river had a discharge of 790 second-feet, which is practically the same as its discharge at 3.5 feet in 1917, indicating that approximately as much water passed the gauge in 1922 as in 1917, when the stage ranged a foot higher. In the absence of discharge measurements prior to 1917 it is impossible to say with certainty that the flow has not diminished with the lowering of the surface of the stream 3.42 feet since 1905, but it seems reasonable, in the light of the past five years' record, to assume that it has not.

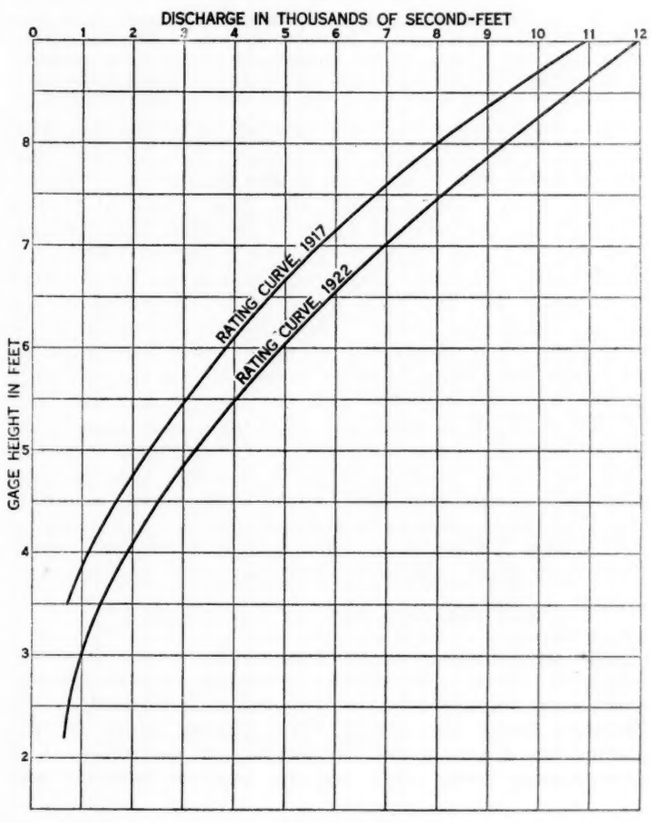

FIG. 3.—Change in rating curve of discharge of Kansas River, at Topeka, Kans.

The cause of the lowering of the channel is not far to seek. The sand of which the river bed is composed was long ago found to be of excellent quality for concrete work and almost 200,000 cubic yards are removed annually in the immediate vicinity of the gage and for a distance of half a mile below it for this purpose. Evidently this has lowered the control of the stream channel for some distance in this particular section of the river. In the absence of other gage readings nearer than Wamego, 35 miles upstream in an air line, and Bonner Springs, about the same distance below, neither of which has a record covering more than a few years, it is not possible to state how far this lowering effect has extended, but rating curves of discharge for the past five years at those places do not suggest any material change in the river bed, also there has not been much sand-dipped out of the river at either point.

It is difficult to estimate just what effect this lowering of the river channel at Topeka will have on high stages. Absence of high water during the last two years has prevented obtaining discharge measurements above 11 feet, but the approach of the rating curve of 1922 toward that of 1917 at higher stages indicates that at flood stage, 21 feet, there will not be much difference between the present volume of water passing the gage and the amount that passed at the same stage several years ago. However, the matter is worth investigation, especially as the decrease in height of the stages is a progressive affair and may go several feet farther in the next few years.

An immediate effect of the lowering of the stages is that it has been necessary to tear out the concrete floor of the well in which the float of the self-registering gauge at Topeka operates and lower it more than a foot at a considerable expenditure of time and money. When the gauge was installed five years ago it was assumed that it would register any low stage that might occur and this was borne out by past records, but on several occasions in the last year of the record the river was so low the float rested on the bottom of the well.

SNOWFALL AND THE RUN-OFF OF THE UPPER RIO GRANDE.

By CHARLES E. LINNEY, Meteorologist.

[Weather Bureau Office, Santa Fe, N. Mex., December 21, 1922.]

SYNOPSIS.

The run-off which appears in the upper Rio Grande is almost wholly derived from the melting of snow that falls on the elevated parts of the drainage basin in Colorado and New Mexico. Statistics are presented showing the mean monthly and annual snowfall as derived from an average of 10 stations in Colorado and 12 in New Mexico for the period of years, 1909–1922. The measured discharge of the Rio Grande, near Buckman, N. Mex., as determined by the United States Geological Survey is also given for the corresponding period and for earlier years.

The average annual snowfall is 97 inches. Assuming that the equivalent of the snow was 0.08 inch of water per inch of snow, and assuming further that there was no loss by diversion or otherwise and that but 29 per cent of the precipitation was measured as run-off, that amount of snowfall would correspond to 1,332,000 acre-feet for the area above Buckman, N. Mex. This amount corresponds very closely with the average run-off for the entire term of years but is somewhat below the average for the 13 years, 1909–1922. The uncertain factors in the above approximation are the water content of the snow, diversion, and other losses which can not easily be approximated.

In a consideration of the snowfall in connection with the run-off of the upper Rio Grande it is obvious that the calendar year is unsuited to the discussion or tabulation of data; rather should the year conform, in fair measure, to the natural cycle of snowfall and melting, and an effort be made to choose a period which will most nearly set apart the run-off which can be expected from snow, the resulting water to be measured as the stream discharge. After some consideration of the probable date when practically all snow water has found its way into the stream, I have chosen a year (or probably better, a cycle) to begin with the first of August. But in this choice it is admitted, of course, that there is an intermingling of rain and snow. It is thought, however, that the date chosen sets forth a cycle that is least affected, except one that would completely eliminate the late spring, summer, and fall run-off. In some of my figures I have done this, setting forth the results from snow alone, which will be apparent in the discussion.

THE PRECIPITATION OF THE DISTRICT.

The precipitation of winter which occurs over the southern Rocky Mountains pertains to the Pacific weather type, somewhat obliterated and diffused by the distance from the ocean. The humid winds of the Pacific are drawn across the region by the influence of low-pressure areas over regions near or remote, and step by step in its journey eastward the atmosphere discharges its moisture over the graduated plateau and mountain ranges, till it reaches the crowning peaks where occurs its maximum fall, as, for instance, around the rim of the San Luis Basin in Colorado and over the great crests of the Sangre de Cristo in New Mexico, between Taos and Colfax Counties, attaining there a maximum snowfall of probably 300 inches annually. Altitude has much to do with this; in fact it is probably the most important factor, next to the eastward movement of the moisture-bearing winds. General Greely gives the following table of altitude areas and precipitation for Colorado and New Mexico.[1]

State.	Elevations (feet).	Area (square miles).	Cubic miles, precipitation.	Average precipitation (inches).
Colorado	4,000 and less	8,773	1.5	11.15
	4,000 to 5,000	18,031	3.2	11.78
	5,000 to 7,000	31,314	6.1	12.74
	7,000 and over	45,885	9.2	13.12
Whole State		104,000	20.0	12.61
New Mexico	4,000 and less	6,996	1.1	10.14
	4,000 to 5,000	34,407	6.1	11.59
	5,000 to 7,000	57,503	12.4	14.13
	7,000 and over	22,300	5.6	16.34
Whole State		121,200	25.2	13.62

In other words, considering New Mexico only, 71 per cent of the possible precipitation of the State occurs above 5,000 feet upon 66 per cent of the land area, while over the really worth-while elevations for the storage of snow (7,000 feet and over) only 22 per cent of the precipitation occurs upon less than 20 per cent of the land area. The ratio is somewhat greater for the Rio Grande drainage, since but a small part of it is below 5,000 feet, and a relatively large part is above. A very considerable part of the 22,300 square miles of the State which is above 7,000 feet is within the drainage area of the Rio Grande, but not within the district under discussion, which includes only the northern part of New Mexico, an area of approximately 6,400 square miles, and the southern part of Colorado, an area of approximately 7,300 square miles.

[1] Irrigation and water storage, Ex. Doc. No. 287, 51st Cong., 2d sess., 1891.

Some idea of the increase of precipitation with altitude can be gained from a report of the late Robert R. Briggs, of the Arizona climatic service, who compiled a table of July records from 104 stations for 18 years, as follows:[2]

Average for 18 years of July rainfall in Arizona at different altitudes.

Number of stations.	Elevation (feet).	Average rainfall (inches).	Average number of rainy days.
8	Below 1,000	0.33	1
16	1,000 to 2,000	0.63	5
11	2,000 to 3,000	2.72	10
16	3,000 to 4,000	2.79	10
20	4,000 to 5,000	3.95	14
16	5,000 to 6,000	4.05	12
10	6,000 to 7,000	5.01	17
5	7,000 to 8,000	5.70	21
2	8,000 or above	7.12	29

SNOWFALL AND WATER CONTENT.

Freshly fallen snow, as shown by our experience in the western mountain country, has a water equivalent of from 3 to 10 per cent, mostly around 5 to 8 per cent, according to altitude, temperature, time of day of the fall, season, etc. In consistency it varies from the light feathery type, the powdery, little pill, or small hail type, to the wet clinging type (with many intervening kinds). The water equivalent of the first is probably 3 to 5 per cent, the second 5, 6, or 7 per cent, and the third 8 to 10 per cent. Accumulated snow, however, rapidly becomes of higher water content as it is compacted by the weight of the upper layers in the recurring falls of snow, aided by absorption of the sun's rays, settling by wind, and more or less heat even from the earth itself. It is possible also that some water is added by condensation from the atmosphere direct, expecially in the higher districts where cloud formations drag across the mountain tops and fogs are thus much more frequent. Tests of snow which has accumulated for a considerable time, show that the water content goes upward to 20, 30, 40, and even 60 per cent of its volume, becoming almost ice.

Various snow samplings and snow surveys have been made in the western mountain country and have shown water content from 20 to 40 per cent or greater. Mr. H. S. Cole, in measuring the drifts in Nevada at 9,000 feet and in snow to a depth of 14.5 feet found as high as 46 per cent of water, and in another of 13.5 feet, found it contained 38.4 per cent water. Measurements in Maple Creek Canyon in Utah, in depths averaging from 23 to 52 inches, showed 22 to 35 per cent water content. Measurements in Big Cottonwood Canyon, in depths up to 9 feet, showed a water content from 33 to 48 per cent, and one at 11.5 feet, in a snow slide, showed up to 56 per cent. When the season of rapid melting is at hand the proportion may easily rise to 50, 60, 70, and even 85 per cent, really becoming ice banks.

Mr. Alexander McAdie, in an account of the very great snowfall at Summit, Calif. (the greatest in the United States, although at an altitude of only 7,017 feet), has shown that 86 per cent of the annual precipitation occurs as snow, averaging 443 inches, or about 48 inches of water. The snowfall has risen as high as 783 inches, and has never fallen below 153.8 inches in many years' record. The greatest depth (783 inches) amounted to 80.1 inches of water and the least (153.8 inches) to 21.8 inches of water. A test of the water content in this remarkable region showed at the surface 34 per cent water, at 64 inches, 45 per cent, and at 174 inches 59 per cent.

INFLUENCING FACTORS.

The character of the watershed and the local environment have much to do with the accumulation of snow and the resulting run-off configuration, topography, vegetation and forestation (or the lack of these), character and kind of soil or rock, and many other things enter into the accumulation of snow, and in greater or less degree the run-off therefrom. When melting is active in the spring (and even at times during the winter, when warm rains fall over lower levels) a fairly heavy rain may result in sudden and unusually large run-off. On the other hand, a cold spring, with the season warming up slowly, may result in long drawn out run-off, large local absorption, and even the actual elimination of what earlier had promised to be a fair run-off. Streams like the Rio Grande, where the spring run-off is so largely dependent upon the accumulation of snow, respond quickly to these limiting factors. Even changes in the character of the watershed by agricultural and lumbering pursuits have an effect. These and other things change the character and amount of flow from season to season.

EARLY VIEWS OF THE RUN-OFF.

In a discussion of the relation between precipitation and the run-off, the following appears:[3]

> Comparison between the precipitation and run-off for the various parts of the United States has been made by Henry Gannett, of the United States Geological Survey, who found that where the annual precipitation is less than 20 inches no definite relation exists, as apparently the needs of vegetation require that much. With less than this amount of precipitation the run-off will depend almost entirely on the intensity of the rainfall rather than upon the total amount. Short violent storms will cause a comparatively large percentage of the precipitation to run off as surface water, whereas the same or even larger precipitation occurring as gentle showers may have practically no run-off, the water finding its way into underground channels, evaporating, or being absorbed by vegetation. As there are only a few points in the Rio Grande Basin where the annual rainfall exceeds 20 inches, it is seen that no definite relation exists between precipitation and the run-off. Any possible relation is still further complicated by diversion of the waters for irrigation and by the large nonproducing areas in the upper parts of the drainage area.

That these conclusions were probably overdrawn appears to be shown by the fact that later Mr. Gannett estimated that a mean annual run-off of .3 inches was to be expected from the lower valleys and mesas of the upper Rio Grande in New Mexico and of the San Luis Valley of Colorado, increasing to 10 inches or more over the higher mountain areas of the San Juan, Culebra, and Sangre de Cristo Ranges. In other words, he estimated that about one-third of the annual precipitation reached the streams, since the annual amount over the lower valleys and mesas of northern New Mexico and the San Luis Valley of Colorado averages from 8 to 10 or 12 inches, increasing to 15, 17, or 20 over the foothills, and to 25 or possibly 30 inches over the higher mountain areas, a probable average for the district under discussion of about 15 inches annually. This is nearly equally divided between rain and snow. At the Wagon Wheel Gap experiment station, the results gave approximately 50-50 basis, and the run-off, from the several years record, averaged 29 per cent.[4]

[2] Variations in precipitation as affecting water works engineering. Am. W. W. Assoc., 35:0, 85, 86. 1916.

[3] U. S. G. S. Water Supply Paper No. 358, p. 24.

[4] MO. WEATHER REV. SUPPLEMENT NO. 17, p. 32.

Year.	Precipitation.	Run-off.
	Inches.	*Inches.*
1912	21.30	8.4
1913	18.63	4.8
1914	22.64	5.6
1915	19.97	5.4
1916	22.71	5.6
1917	22.88	9.6
1918	18.90	3.2
Mean	21.90	6.1
Percentage		29.0

The remainder of the precipitation, it was estimated, was disposed of as follows: Seventeen per cent lost by interception, 18 per cent lost by transpiration, and 36 per cent loss by evaporation.

MELTING SNOW.

Snow occurs from September or October to April or May, and the period from about the 1st of October may properly be considered as the period of storage, when stream flow should be reduced to a minimum. The snow of September rarely lies, but is lost by evaporation, melting, etc., and a considerable part of the October snow is lost in like manner. Little of it, however, really reaches the streams, except possibly later as underground water. Snow, of course, comes earlier and lasts longer in the high altitudes, and disappears earliest from the lower levels and the south slopes. North slopes in fact may be, and often are, over limited areas permanently covered with snow. Snow does not begin to accumulate on south slopes until well into cold weather and goes with the first increasing warmth. It begins to melt on the south slopes in February, but the resulting water does not quickly become available for stream flow, or even to replenish ground water, since the water first percolates into the snow itself, and does not reach the soil till a later stage of the melting cycle. Melting is greatly affected by slopes and air temperature, and on south slopes melting is often completed before it is even fairly started on north slopes or in the deep canyons. Yet these south slopes contribute little to the actual run-off, the moisture mostly going to underground flow.

Experiments indicate that the flow of water from melting snow is determined by gravity, and its speed is conditioned upon the porosity of the snow directly underneath. Professor Henry concludes that the run-off from melting snow must reach the stream largely through underground channels. When the snow melts slowly the opportunity for percolation into the soil is large, and any surface run-off of consequence should not be expected until the time of maximum melting, when the surface run-off from north slopes is probably greater than ever happens in the case of rainfall. This may be due to the fact that the shed is then much like a roof, probably with frozen soil and practically no percolation possible.

Snow melts in appreciable measure when the shade temperature rises to or above freezing. Melting progresses in somewhat increasing ratio as the temperature rises, varying, however, with the changing seasons, the winds, the humidity, cloudiness, etc., as well as the character of the snow itself and the character of the soil or rock beneath. On the other hand, melting is checked and often largely prevented by the recurrence of cold. As an example of almost complete absorption it may be noted that there was practically no run-off in the spring of 1904, and but little in the springs of 1899, 1902, and 1918.

THE RIO GRANDE RUN-OFF.

One might almost conclude, as we have earlier quoted, that the run-off does not bear any relation to the snowfall, but as a matter of fact they are closely related, so closely that the plotted curve of the one can almost be substituted for the other. A number of rather ingenious formulæ have been compiled in attempts to express this relationship. Among the most recent is that of Mr. Adolph F. Meyer. Others have attempted it, but Engineer Birkenbine concludes that [2]—

> Such formulæ do not form a reliable means of building up a chronological monthly record of run-off from precipitation records alone. Their employment is strictly limited to sheds for which long and accurate monthly meteorological records of precipitation, temperature, etc., are compiled * * *. Under the circumstances the run-off computed with tentative coefficients may be compared with the corresponding actual run-off, where known, and the first assumption as to the proper watershed coefficient modified in the light of this comparison.

Mr. Meyer himself says (p. 1060, Trans. Am. Soc. C. E., Vol. LXXIX):

> Let it be understood at the outset that the writer does not claim to have discovered a method of computing daily or even monthly run-off from rainfall and other physical data which obviates the necessity for stream measurements. He believes, however, that he has found a method of computing the annual run-off from widely different watersheds with considerable accuracy, and of computing a reasonable distribution of such run-off through the various months of the year for most of such watersheds.

Averaging a fair representation (24) of the snowfall stations over the Rio Grande watershed north of the river station at Buckman, gives an average seasonal snowfall of about 97 inches, and if this were on the ratio of 0.08 inch of water to each inch of snow the result would be 7.76 inches precipitation; if, however, it were in the proportion of 0.07 inch to each inch of snow the result would be 6.79 inches of precipitation. On the basis of 29 per cent run-off, which actually occurred at the experiment station at Wagon Wheel Gap, Colo., the first ratio would give 2.25 inches run-off, while the second would give 1.97 inches. In the first instance a consideration of the acreage would show a full run-off of 1,332,000 acre-feet, not allowing anything for loss, diversion, use or other items, a figure which is not far from the actual annual average run-off, as shown through a period of 23 years. If, however, the second ratio were used as the amount of water which would find its way to the stream, the total run-off would be 1,166,300 acre-feet, an amount which is somewhat below the average annual run-off and in excess of the average spring run-off. These figures are not given as a formula, but simply to show that an approximation can be made and that there is hope of a fairly correct formula in time.

THE DATA USED.

A consideration of the data given discloses the great height and flow that occurs in the months of May and June—from 60 to more than 80 per cent of the spring run-off occurs in these two months, or about one-half of the average annual flow. At times it has been phenomenal, thus in 1920, 1,500,000 acre-feet passed the Buckman station in the two months. An average of almost 900,000 acre-feet occurs between the first of March and the last of June.

The greatest annual flow thus far noted was 2,461,600 acre-feet in 1904–5, while during the prior year the amount was only 269,500 acre-feet, the smallest known record. The stream was dry that year below Albuquerque for many months. The greatest monthly flow was 860,000 acre-feet in May, 1920, and the least (for a full month) 10,100 in August, 1900.

On the snow side of the data (since 1909) the winter of greatest fall was that of 1915-16, closely followed by 1911-12, when the station at the old mining camp of Anchor measured 483 inches—over 40 feet of snow. The least seasonal fall was in the winter of 1917–18, when few stations over the watershed had 100 inches, and the Anchor station had but 205 inches.

Explanation of the tables.—Table 1 contains the mean monthly snowfall for the upper drainage basin of the Rio Grande, viz, those areas contained within the States of Colorado and New Mexico. The figures in the table are the means of individual stations throughout the drainage basin in both States. The number of stations in Colorado averaged 10, in New Mexico 12, and these numbers were fairly constant throughout the period of measurement.

Table 2 contains the monthly discharge measurements as made by the water resources branch of the United States Geological Survey, near Buckman, N. Mex. The figures in the units and tens places have been rounded off so that the figures in the table represent hundreds of acre-feet.

Table 3 is a summation of annual discharge in thousands of acre-feet and the average snowfall for the upper part of the watershed in inches and tenths. Snowfall data for the early part of the run-off period are lacking.

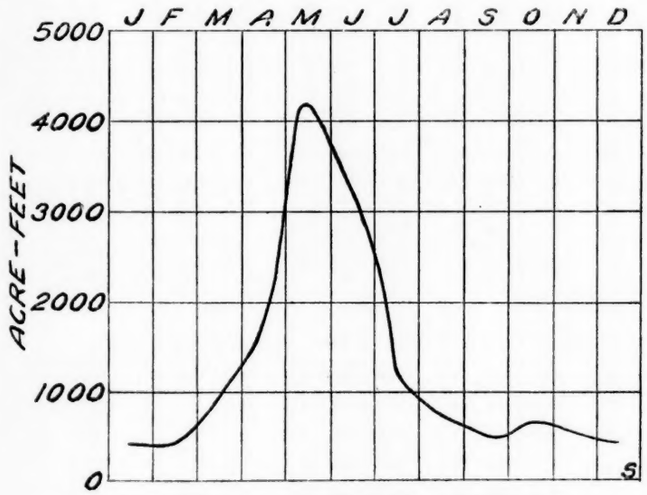

FIG. 1.—Discharge of Rio Grande at Buckman, N. Mex. (acre-feet).

TABLE 1.—*Average monthly snowfall, upper Rio Grande (inches and tenths).*

COLORADO.

Year.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Season.
1909–10	1.5	6.9	21.8	21.4	12.9	11.8	7.8	9.7	2.4	0.0	96.2
1910–11	0	7.9	7.6	12.3	12.4	31.0	9.7	6.2	0.5	T.	87.6
1911–12	0	10.3	12.0	15.4	5.5	10.5	33.8	16.4	4.2	1.6	109.7
1912–13	0.3	10.1	3.1	6.7	11.3	19.1	14.0	7.6	0.1	T.	72.3
1913–14	4.9	3.3	11.6	22.2	16.5	8.4	9.6	15.1	3.5	0.1	95.2
1914–15	1.0	5.2	0.4	15.4	12.7	23.0	7.8	16.7	12.7	0.5	95.4
1915–16	0.8	1.7	7.8	22.6	36.6	8.3	14.8	20.0	2.5	0	115.1
1916–17	T.	6.9	4.2	18.0	18.3	16.5	13.9	27.9	15.7	0	121.4
1917–18	0.6	1.6	4.0	1.7	23.1	14.2	17.0	5.5	1.2	0	68.9
1918–19	0	3.4	23.5	20.3	2.0	15.9	17.6	6.6	1.2	0	90.5
1919–20	0.4	11.8	25.4	13.2	8.6	18.0	16.0	27.0	5.0	T.	125.4
1920–21	0.3	30.7	4.9	17.5	12.7	9.4	11.2	20.5	2.9	0	110.1
1921–22	0	3.3	4.3	15.1	30.4	14.2	21.1	8.0	5.9	0.2	102.5
Average..	0.8	7.9	10.0	15.5	15.6	15.4	14.9	14.4	4.4	0.2	99.1

NEW MEXICO.

1909–10	T.	2.6	10.0	18.6	13.9	17.9	6.6	5.6	0.8	0.0	76.0
1910–11	0	7.1	6.1	11.3	10.0	27.8	8.4	2.1	0.5	0	73.3
1911–12	0	9.2	19.2	13.7	6.3	10.2	38.2	24.6	7.5	T.	125.9
1912–13	0	3.5	5.6	6.5	15.7	30.5	22.6	8.6	T.	0	93.0
1913–14	5.7	0.8	11.0	32.2	10.1	9.4	11.8	21.7	7.0	0	109.7
1914–15	0	6.3	0.2	21.4	16.7	24.0	15.5	14.1	18.6	5.4	122.2
1915–16	T.	0.8	6.7	18.5	53.2	6.8	21.4	19.8	2.8	0	130.0
1916–17	0	2.6	1.6	15.1	18.6	16.8	14.8	15.8	22.5	0.1	107.9
1917–18	T.	0.4	1.0	0.8	26.7	16.0	17.0	6.5	3.1	0	71.5
1918–19	0.3	3.5	16.0	26.8	3.3	23.8	21.2	12.8	2.1	0.6	110.4
1919–20	T.	4.9	15.1	13.7	7.0	9.8	18.2	15.4	0.8	0	84.9
1920–21	T.	9.1	4.0	19.6	12.8	10.6	7.8	12.3	1.3	0.1	77.6
1921–22	0	1.9	1.8	9.3	13.9	15.0	12.3	3.5	1.9	T.	59.6
Average..	0.5	4.1	7.6	16.0	16.0	15.8	16.6	12.3	5.3	0.5	95.7

Combined average for drainage basin in Colorado and New Mexico.

Year.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Season.
	The watershed.										
1909–10	0.6	3.8	15.6	19.8	13.4	15.1	7.1	7.5	1.5	0.0	84.4
1910–11	0	7.5	6.8	11.9	11.1	29.3	9.0	4.2	0.5	0	80.4
1911–12	0	9.6	16.0	14.4	6.0	10.4	36.5	19.5	6.3	0.6	119.3
1912–13	0.1	6.5	4.5	6.6	13.7	25.3	18.7	8.2	0.1	T.	83.7
1913–14	5.4	1.5	11.2	27.9	13.0	9.0	10.9	19.0	5.4	T.	103.3
1914–15	0.5	5.8	0.3	18.7	15.0	23.5	12.0	15.4	15.7	2.9	109.8
1915–16	0.4	1.2	7.2	20.4	44.9	7.5	18.1	19.9	2.6	0	122.2
1916–17	T.	4.7	2.0	16.5	18.4	16.6	14.4	21.2	19.5	T.	113.3
1917–18	0.2	0.9	2.2	1.1	25.2	15.2	17.0	6.1	2.3	0	70.2
1918–19	0.2	3.5	20.0	24.1	2.8	20.5	19.7	10.1	1.7	0.3	102.9
1919–20	0.2	8.2	19.9	13.5	7.7	13.5	17.1	20.6	2.7	T.	103.4
1920–21	0.1	16.7	4.3	19.2	12.7	10.1	9.4	15.3	1.9	T.	89.7
1921–22	0	2.4	2.8	11.9	21.0	14.6	16.0	5.2	3.6	0.1	77.6
Average..	0.6	5.6	8.7	15.8	15.8	16.2	15.8	13.2	4.9	0.3	96.9

TABLE 2.—*Monthly discharge, in acre-feet, of Rio Grande, near Buckman, N. Mex. (given to hundreds only, units and tens rounded off).*

Year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Annual.
1909–10	898	2,030	812	291	355	374	313	2,000	3,050	4,260	1,300	110	15,793
1910–11	221	118	[1] 87	338	323	477	415	916	1,500	4,080	3,400	3,500	15,375
1911–12	695	643	3,360	1,320	775	486	428	947	1,390	7,010	1,940	683	19,677
1912–13	530	383	382	383	325	338	359	489	1,460	1,800	1,120	378	7,947
1913–14	168	258	499	493	352	294	428	916	1,640	3,710	2,530	1,160	12,448
1914–15	1,170	833	873	560	364	284	310	482	1,160	2,390	2,560	915	11,901
1915–16	712	434	399	355	387	441	496	1,940	2,660	5,510	3,250	985	17,569
1916–17	1,320	507	316	948	556	421	415	648	1,630	3,120	4,550	1,960	16,391
1917–18	376	278	248	374	352	327	326	678	714	1,850	1,360	650	7,533
1918–19	264	188	168	232	445	357	336	862	3,150	5,700	2,010	1,380	15,092
1919–20	889	361	533	536	541	485	777	858	1,420	8,600	7,050	1,840	23,890
1920–21	597	373	467	625	484	451	471	1,020	723	2,589	6,720	1,080	15,600
1921–22	1,920	947	474	498	538	535	502	761	1,070	4,010	3,690	820	15,762
Mean....	751	566	664	535	446	405	429	963	1,659	4,202	3,191	1,189	15,000

[1] Incomplete.

TABLE 3.—*Annual discharge of Rio Grande, near Buckman, N. Mex. (August to July), in thousands of acre-feet.*

[Add three ciphers to figures in table.]

Year.	Discharge.	Snowfall (inches).
1895–96	852	.....
1896–97	1,708	.....
1897–98	1,240	.....
1898–99	652	.....
1899–1900	762	.....
1900–1	816	.....
1901–2	478	.....
1902–3	1,666	.....
1903–4	270	.....
1904–5	2,462	.....
1909–10	1,579	84.4
1910–11	1,538	80.4
1911–12	1,968	119.3
1912–13	795	83.7
1913–14	1,255	103.3
1914–15	1,190	109.8
1915–16	1,757	122.2
1916–17	1,639	113.3
1917–18	753	70.2
1918–19	1,509	102.9
1919–20	2,389	103.4
1920–21	1,560	89.7
1921–22	1,576	77.6
Mean	1,322	96.9

FRANKENFIELD ON THE SPRING FLOODS OF 1922.[1]

ALFRED J. HENRY.
[Weather Bureau, Washington, D. C., February 25, 1923.]

In accordance with custom, a rather full abstract of the material contained in MONTHLY WEATHER REVIEW SUPPLEMENT No. 22 is herein presented. Those who may find a special interest in the subject and desire to obtain the full report can do so by applying to the Chief of Weather Bureau while the bureau's supply lasts. Afterwards application should be made to the Superintendent of Documents, Washington, D. C.—EDITOR.

The flood of 1922 in the Mississippi was unique in at least two respects, first, in the fact that with the exception of the Tennessee and Cumberland Rivers, the main stream and its principal tributaries were in flood at the same time. The excepted streams, however, contributed a very considerable volume of water during the early days of the flood; they can not, therefore, be entirely eliminated from consideration. The second striking feature of the flood was the high stages in the Mississippi from the mouth of the Arkansas to the Passes due to the great volume of water discharged by the Arkansas and White Rivers. It may be added in this connection that the United States engineers hold that a large part of the excess in the flood stage, especially at Arkansas City, Ark., was due to the closure of Cypress Creek, a small stream that empties into the Mississippi just above Arkansas City. Levees were constructed along that creek in 1921.

The crest stages reached at important points along both the main stream and its principal tributaries are shown in Table 1 below. For comparative purposes the crest stages of ten great previous floods in the Mississippi have been added.

[1] MO. WEATHER REV. SUPPLEMENT No. 22, Washington, D. C., 1923.

TABLE 1.—*Crest stages and dates during lower Mississippi River floods from 1882 to 1922, inclusive.*

[Highest stages of record in bold-face type.]

Station.	River.	Flood stage.	1882		1883		1893		1897		1903		1907	
			Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.
Cincinnati, Ohio	Ohio	52	58.6	Feb. 21	66.3	Feb. 15	50.6	May 2	50.1	Mar. 12	53.2	Mar. 5	65.2	Jan. 21
Mount Carmel, Ill.	Wabash	15					24.5	May 8[1]	26.4	Mar. 13	22.3	Mar. 12	24.5	Jan. 28
Nashville, Tenn.	Cumberland	40	38.3	Feb. 22	41.6	Feb. 14	19.9	May 9	48.7	Mar. 21	40.7	Mar. 9	28.2	Jan. 24
Johnsonville, Tenn.	Tennessee	31	43.8	Jan. 31	29.0	Feb. 2[1]	27.0	May 13	**48.0**	Mar. 24	33.7	Mar. 11	14.5	Jan. 27
				Feb. 2										
St. Louis, Mo.	Mississippi	30	28.2	Feb. 22	26.2	Feb. 26	31.5	May 3	23.2	Mar. 28[1]	25.8	Mar. 11	26.3	Jan. 23
Cairo, Ill.	Ohio	45	51.9	Feb. 26	52.2	Feb. 27	49.3	May 9[1]	51.6	Mar. 25[1]	50.6	Mar. 15[1]	50.4	Jan. 27
New Madrid, Mo.	Mississippi	34					38.1	May 9[1]	40.2	Mar. 26[1]	39.5	Mar. 16[1]	39.3	Jan. 28[1]
Cottonwood Point, Mo.	....do.	35	37.5	Feb. 28	37.8	Feb. 28	36.6	May 12[1]	39.4	Mar. 22[1]	40.0	Mar. 20	38.4	Jan. 30[1]
Memphis, Tenn.	....do.	35	35.2	Mar. 6[1]	34.8	Mar. 5[1]	35.2	May 15[1]	37.1	Mar. 19[1]	40.1	Mar. 20	40.3	Feb. 3
Helena, Ark.	....do.	44	47.2	Mar. 9	46.9	Mar. 8[1]	48.0	May 25	51.8	Apr. 4	51.0	Mar. 25[1]	50.4	Feb. 5[1]
Pine Bluff, Ark.	Arkansas	25	26.6	Feb. 25	25.4	Feb. 20	28.5	May 5	[2] 21.4	Mar. 21	[2] 23.3	Mar. 13	21.0	Jan. 26
Clarendon, Ark.	White	30					33.9	May 11	31.9	Mar. 30	32.6	Mar. 20	32.5	Jan. 9[1]
Arkansas City, Ark.	Mississippi	48	47.0	Feb. 28	46.3	Mar. 11[1]	50.3	May 29	51.9	Mar. 29	53.0	Mar. 27[1]	52.1	Feb. 8
Greenville, Miss.	....do.	42	41.7	Feb. 27[1]	40.4	Mar. 10[1]	44.3	May 29	46.8	Mar. 29	49.1	Mar. 27	47.3	Feb. 8[1]
Lake Providence, La.	....do.		38.2	Feb. 28[1]	36.5	Mar. 11[1]	41.8	May 15[1]	44.5	Mar. 30	46.5	Mar. 27	46.3	Feb. 9[1]
			38.3	Mar. 20										
Vicksburg, Miss.	....do.	45	44.8	Mar. 1[1]	43.1	Mar. 14[1]	48.3	May 22[1]	52.5	Apr. 16	51.8	Mar. 27[1]	49.7	Feb. 11
			48.8	Mar. 20[1]										
Natchez, Miss.	....do.	46	47.8	Mar. 28[1]	44.0	Apr. 7[1]	46.8	May 22[1]	49.8	Apr. 29[1]	50.4	Mar. 28[1]	48.9	Feb. 13[1]
Alexandria, La.	Red	36					25.6	June 8	26.3	Apr. 15[1]	36.2	Mar. 27[1]	22.8	Jan. 13[1]
Baton Rouge, La.	Mississippi	35	36.0	Mar. 26	35.1	Apr. 9	38.4	June 23	40.6	May 12[1]	40.0	Apr. 7[1]	37.3	Feb. 14[1]
Donaldsonville, La.	....do.	28					30.6	June 23	32.8	May 13	32.2	Apr. 4[1]	30.1	Feb. 16[1]
New Orleans, La.	....do.	18	16.2	Mar. 27	16.6	Apr. 7[1]	17.9	June 24	19.6	May 8[1]	20.3	Mar. 27[1]	19.8	Feb. 13[1]
Melville, La.	Atchafalaya	37					34.5	June 25[1]	36.1	May 15	38.7	Apr. 4[1]	37.7	Feb. 19[1]
Monroe, La.	Ouachita	40	**49.7**				38.6	June 21[1]	37.9	Apr. 9[1]	44.5	Mar. 26[1]	38.5	Jan. 23[1]

Station.	River.	Flood stage.	1912		1913		1916		1920		1922	
			Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.
Cincinnati, Ohio	Ohio	52	51.7	Apr. 5[1]	69.9	Apr. 1	43.9	Feb. 4	54.6	Mar. 22	52.2	Mar. 18
									52.6	Apr. 23	48.2	Apr. 19
Mount Carmel, Ill.	Wabash	15	23.2	Apr. 7[1]	**31.0**	Mar. 30	**26.7**	Feb. 6	**20.0**	Mar. 22	24.1	Mar. 23
									23.6	Apr. 28[1]	26.0	Apr. 23
Nashville, Tenn.	Cumberland	40	46.6	Apr. 7[1]	44.9	Apr. 2	20.9	Feb. 3	35.8	Mar. 16	45.1	Mar. 16
									24.0	Apr. 27	21.7	Apr. 21
Johnsonville, Tenn.	Tennessee	31	35.4	Apr. 6	33.3	Mar. 29	25.0	Jan. 27	29.1	Mar. 17	36.4	Mar. 15
									24.9	Apr. 28	20.7	Apr. 23
St. Louis, Mo.	Mississippi	30	30.8	Apr. 5	25.8	Mar. 27	31.5	Jan 31	27.8	Mar. 30	23.9	Mar. 17[1]
									28.0	Apr. 24	34.0	Apr. 19
Cairo, Ill.	Ohio	45	54.0	Apr. 6[1]	**54.8**	Apr. 4[3]	53.4	Feb. 4	51.4	Mar. 31	53.6	Mar. 25[1]
									49.5	May 1[1]	53.5	Apr. 25
New Madrid, Mo.	Mississippi	34	44.0	Apr. 5[1]	**44.5**	Apr. 9[1]	41.9	Feb. 5[1]	40.2	Apr. 1	41.6	Mar. 27[1]
									38.6	May 3	41.7	Apr. 26[1]
Cottonwood Point, Mo.	....do.	35	42.0	Apr. 11[1]	**42.3**	Apr. 11[1]	39.5	Feb. 7	37.6	Apr. 3[1]	38.5	Mar. 28[1]
									36.5	May 4[1]	38.4	Apr. 28
Memphis, Tenn.	....do.	35	45.3	Apr. 6	**46.5**	Apr. 10	43.5	Feb. 9	40.3	Apr. 5	42.6	Mar. 31[1]
									38.7	May 7	42.3	Apr. 29[1]
Helena, Ark.	....do.	44	54.4	Apr. 21	**55.2**	Apr. 22	53.4	Feb. 11	50.1	Apr. 8[1]	52.3	Apr. 3[1]
									48.8	May 9[1]	53.1	May 3
Pine Bluff, Ark.	Arkansas	25	26.2	Apr. 4	20.4	Apr. 14	**29.6**	Feb. 3	23.5	Mar. 31	17.7	Mar. 22
									19.1	May 21	26.0	Apr. 16
Clarendon, Ark.	White	30	32.6	Apr. 14	30.4	Apr. 15[1]	**38.5**	Feb. 8	29.6	Apr. 8[1]	27.8	Mar. 23[1]
									29.2	May 19[1]	30.7	Apr. 11[1]
Arkansas City, Ark.	Mississippi	48	55.4	Apr. 12	55.1	Apr. 21[1]	56.4	Feb. 10[1]	54.0	Apr. 11[1]	**58.0**	Apr. 22[1]
									52.4	May 13[1]	57.7	May 3[1]
Greenville, Miss.	....do.	42	50.6	Apr. 12	50.4	Apr. 21	50.8	Feb. 11[1]	47.0	Apr. 16	**52.1**	Apr. 25[1]
									45.4	May 13	52.0	May 3[1]
Lake Providence, La.	....do.		48.2	Apr. 12	48.0	Apr. 21	48.8	Feb. 15	45.4	Apr. 15[1]	**49.5**	Apr. 27[1]
									44.3	May 13[1]	49.3	May 6[1]
Vicksburg, Miss.	....do.	45	52.1	Apr. 12	52.3	Apr. 27[1]	53.9	Feb. 15	50.8	Apr. 19[1]	**55.0**	Apr. 28[1]
									50.4	May 14[1]	54.7	May 7[1]
Natchez, Miss.	....do.	46	51.4	Apr. 14[1]	52.4	Apr. 26[1]	53.6	Feb. 15	51.5	Apr. 28	[4] **55.2**	Apr. 26
									51.2	May 18[1]	[4] 52.8	May 9[1]
Alexandria, La.	Red	36	33.6	Apr. 22	24.2	Apr. 6	36.8	Feb. 16[1]	27.6	Apr. 5	37.1	Apr. 18[1]
									37.1	June 2[1]	37.4	May 10
Baton Rouge, La.	Mississippi	35	43.8	May 11[1]	41.3	May 9	42.6	Mar. 1[1]	40.2	Apr. 30	[4] 44.6	Apr. 27
									41.5	May 22[1]	**45.7**	May 16
Donaldsonville, La.	....do.	28	34.8	May 11	32.7	May 8[1]	34.0	Mar. 1	31.6	May 1[1]	[4] 35.8	Apr. 27[1]
									32.6	May 18[1]	**35.9**	May 16
New Orleans, La.	....do.	18	22.0	May 11	20.5	May 8	21.0	Feb. 28[1]	19.5	Apr. 28[1]	[4] **22.3**	Apr. 24
									20.3	May 17[1]		
Melville, La.	Atchafalaya	37	41.7	May 6[1]	41.5	Apr. 24	43.0	Feb. 14	42.5	May 20[1]	**45.9**	May 14[1]
Monroe, La.	Ouachita	40	46.2	Apr. 22	36.9	Apr. 29[1]	40.6	Feb. 19[1]	41.0	June 5	**42.3**	May 9[1]

[1] And subsequently. [2] Little Rock stage. [3] Absolute crest probably on 7th; nearly stationary from 4th. [4] Crevasse prevented further rise.

In general the above table is self-explanatory, the maximum flood stage for any gauging station may be seen by the full-face figures given in the table; it will be noted, of course, that the maximum stages of record in the lower river occurred in the 1922 flood.

Hydrographs of the 1922 flood for selected stations on the main streams and for a single station on four of its most important tributaries are shown in Figure 1. The time interval in this figure is 5 days. The duration above the flood stage is shown for each station by a dash line.

The order of magnitude of the several floods which have occurred in the Mississippi is placed as follows: The 1922 flood was the greatest below and that of 1913 the greatest above the mouth of the Arkansas, while the 1912 flood might possibly be considered the greatest flood for the entire stream, Cairo, Ill., to the mouth. The author remarks that owing to progressive changes in the levee system comparison with floods previous to 1912 does not lead to any significant conclusion.

CONTRIBUTING CAUSES OF THE FLOOD.

Precipitation as snow was not influential in producing the flood; precipitation as rain, however, was the dominating cause.

Rainfall, amount, character, and distribution.—The rainfall preceding the flood had been quite generous over the Ohio Basin during November and December, 1921, and over the lower Mississippi and upper Tennessee Basins during January, 1922. The rainfall of the last-named month over the Ohio and upper Mississippi Basins was, however, slightly deficient, so that on the whole the excess of November and December, 1921, was probably without influence upon the floods that developed later.

The rains beginning with the last week in February, 1922, were quite general over practically the entire basin and although not heavy enough to produce immediate floods, brought the stages of the streams up to within striking distance of flood stages should heavy rains fall at a later period. The amount of precipitation at representative stations in each of the six subdivisions of the entire Mississippi Basin for each week from February 22 to May 2, 1922, is given in Table 2 below.

TABLE 2.—*Precipitation, inches and hundredths, by weeks, from February 22 to May 2, 1922 (measured at 8 a. m., 75th meridian time).*

Ohio Drainage Basin.

Station.	River.	Feb. 22 to 28.	Mar. 1 to 7.	Mar. 8 to 14.	Mar. 15 to 21.	Mar. 22 to 28.	Mar. 29 to Apr. 4.	Apr. 5 to 11.	Apr. 12 to 18.	Apr. 19 to 25.	Apr. 26 to May 2.	Total.
Warren, Pa.	Allegheny	0.16	1.00	0.68	0.12	0.68	1.19	1.32	1.38	0.21	0.00	6.74
Martin, Pa.	Monongahela	0.40	1.93	0.60	1.38	0.54	0.66	0.17	2.18	0.06	0.12	8.04
Pittsburgh, Pa.	Ohio	0.31	1.44	0.78	0.54	0.83	2.17	0.37	2.70	0.33	0.04	9.51
Parkersburg, W. Va.	do	0.18	1.06	0.84	2.42	0.87	0.87	0.14	3.27	0.18	0.22	10.05
Zanesville, Ohio	Muskingum	0.18	1.17	0.72	1.35	0.70	1.32	0.98	2.70	0.06	0.19	9.37
Hinton, W. Va.	Kanawha—New	0.58	1.76	1.64	1.28	0.68	0.56	Trace.	0.88	0.62	0.90	8.90
Charleston, W. Va.	do	0.40	1.75	0.73	0.82	0.56	1.72	Trace.	2.55	0.63	0.48	9.04
Point Pleasant, W. Va.	Ohio	0.28	2.07	1.06	2.18	1.34	0.90	0.10	1.96	0.00	0.26	10.15
Columbus, Ohio	Scioto	0.24	0.97	0.17	0.66	0.00	0.41	0.88	1.83	0.06	0.28	5.50
Chillicothe, Ohio	do	0.18	1.33	1.08	2.27	0.45	1.60	0.78	3.64	0.15	0.55	12.03
Portsmouth, Ohio	Ohio	0.34	1.50	0.89	2.15	1.35	1.34	1.01	1.91	0.05	0.44	10.98
Cincinnati, Ohio	do	0.31	0.70	0.89	0.68	0.70	1.59	1.02	2.66	0.07	0.57	9.19
Dayton, Ohio	Miami	0.31	0.73	1.42	1.59	0.63	1.44	1.53	3.49	0.02	0.34	11.50
Madison, Ind.	Ohio	0.63	0.91	0.98	2.68	1.42	1.28	1.78	2.16	0.17	0.78	12.79
Frankfort, Ky.	Kentucky	0.42	1.53	2.02	1.96	0.52	1.13	1.19	2.56	0.05	0.40	11.78
Louisville, Ky.	Ohio	0.34	0.74	1.13	2.10	1.55	0.94	1.82	3.46	0.01	0.77	12.86
Bowling Green, Ky.	Barren	1.00	2.68	2.03	2.75	1.55	1.72	1.73	0.60	0.00	2.22	16.28
Woodbury, Ky.	Green	0.71	1.40	1.34	2.28	1.93	1.03	1.47	0.40	Trace.	1.29	11.85
Evansville, Ind.	Ohio	0.47	0.44	1.28	2.57	1.56	2.42	0.92	1.70	0.29	1.16	12.81
Indianapolis, Ind.	White (W. Fork)	0.41	0.52	1.79	2.29	0.76	1.80	4.31	3.86	0.06	0.32	16.12
Elliston, Ind.	do	0.59	0.54	1.12	3.32	0.83	2.63	2.82	3.13	0.13	0.55	15.66
Terre Haute, Ind.	Wabash	0.41	0.56	2.22	2.41	0.81	2.45	3.78	6.25	0.35	0.19	19.43
Mount Carmel, Ill.	do	0.20	0.40	1.05	3.43	1.40	4.19	1.62	2.25	0.75	0.60	15.89
Burnside, Ky.	Cumberland	1.15	2.89	2.84	2.45	0.90	0.78	1.78	0.80	Trace.	2.05	15.64
Nashville, Tenn.	do	1.08	2.90	2.86	1.33	1.02	1.68	1.12	1.11	0.05	2.25	15.40
Chattanooga, Tenn.	Tennessee	1.25	5.06	3.10	0.75	0.70	0.48	1.47	2.05	4.18	0.65	19.69
Decatur, Ala.	do	1.20	3.80	2.90	1.15	0.38	2.63	1.66	2.23	0.12	0.61	16.68
Johnsonville, Tenn.	do	1.01	2.08	2.68	1.72	0.73	1.19	1.51	0.67	Trace.	3.75	15.34
Cairo, Ill.	Ohio	0.47	0.38	1.17	3.21	0.81	3.13	1.22	0.99	0.23	0.91	12.52

Upper Mississippi Drainage Basin.

St. Paul, Minn.	Mississippi	1.03	0.08	0.02	0.66	0.59	0.20	1.01	0.03	0.35	Trace.	3.97
Wisconsin Rapids, Wis.	Wisconsin		0.00	0.09	1.71	0.30	0.28	4.13	0.73	0.13	0.00	7.37
Portage, Wis.	do	2.99	0.36	0.00	1.74	0.41	0.93	2.74	1.78	0.29	0.05	11.29
Davenport, Iowa	Mississippi	1.19	0.09	0.71	0.78	1.03	0.84	2.05	0.71	0.05	Trace.	7.45
Des Moines, Iowa	Des Moines	0.46	0.13	Trace.	1.69	0.26	0.26	2.01	0.40	0.34	0.28	5.83
Hannibal, Mo.	Mississippi	0.44	0.34	2.99	0.20	1.58	1.42	2.62	2.04	0.65	0.01	12.29
Peoria, Ill.	Illinois	0.68	0.11	1.60	0.77	1.04	1.81	1.49	1.09	0.75	0.05	9.39
Beardstown, Ill.	do	0.40	0.24	2.25	0.65	1.42	1.35	1.90	1.85	0.65	0.00	10.71
St. Louis, Mo.	Mississippi	0.63	0.56	2.09	0.86	0.59	1.24	2.57	3.93	0.66	0.24	13.37
Cape Girardeau, Mo.	do	0.46	0.27	1.57	2.01	1.01	3.07	1.91	0.63	0.20	1.00	12.13

Missouri Drainage Basin.

Station.	River.	Feb. 22 to 28.	Mar. 1 to 7.	Mar. 8 to 14.	Mar. 15 to 21.	Mar. 22 to 28.	Mar. 29 to Apr. 4.	Apr. 5 to 11.	Apr. 12 to 18.	Apr. 19 to 25.	Apr. 26 to May 2.	Total.
Topeka, Kans.	Kansas	2.41	0.10	2.92	0.81	0.46	0.78	2.94	0.04	0.56	1.35	12.37
Kansas City, Mo.	Missouri	1.32	0.20	3.28	0.98	1.11	1.60	1.55	0.75	0.28	0.35	11.42
Boonville, Mo.	do	0.98	0.10	3.68	0.39	1.89	2.19	3.67	1.79	0.81	0.37	15.87
Ottawa, Kans.	Osage	0.53	0.54	3.13	0.48	2.99	1.98	4.33	0.66	0.95	1.20	16.79
Osceola, Mo.	do	0.98	0.61	2.34	0.98	1.41	3.18	5.48	1.90	1.25	1.36	19.49
Warsaw Mo.	do	1.15	0.10	2.20	0.85	2.40	2.45	6.81	2.53	1.33	1.75	21.57
Hermann, Mo.	Missouri	0.63	0.32	2.46	0.79	1.24	2.65	6.89	2.92	0.91	0.56	19.37

Arkansas Drainage Basin.

Oswego, Kans.	Neosho	0.88	0.30	4.10	1.25	1.31	2.39	5.37	3.00	2.34	0.37	21.31
Okay, Okla.	Verdigris	1.21	0.33	1.28	0.78	1.21	3.59	1.73	0.00	0.95	1.95	13.03
Woodward, Okla.	North Canadian	1.00	0.24	5.45	0.15	0.75	1.15	1.32	0.00	1.05	1.37	12.48
Oklahoma City, Okla.	do	0.42	0.22	2.33	0.03	1.67	1.80	3.27	Trace.	1.76	1.22	12.72
Calvin, Okla.	Canadian	1.74	0.50	1.43	0.08	1.20	3.85	1.95	0.02	1.02	1.39	13.18
Dodge City, Kans.	Arkansas	1.56	0.01	3.64	0.08	0.03	0.39	0.09	0.19	2.56	1.02	9.57
Wichita, Kans.	do	1.12	0.26	2.97	0.13	0.23	1.13	2.91	0.48	1.40	0.84	11.47
Fort Smith, Ark.	do	1.37	0.62	0.63	0.36	1.85	1.42	1.51	0.82	0.81	1.16	10.55
Little Rock, Ark.	do	1.45	1.45	2.49	0.75	2.76	2.82	0 62	0.19	0.47	1.75	14.75
Pine Bluff, Ark.	do	1.30	2.27	3.34	3.11	2.17	2.64	1.87	0.19	0.06	2.95	19.90
Black Rock, Ark.	Black	1.28	0.86	2.82	1.25	1.29	2.68	1.23	1.55	0.02	2.19	15.17
Batesville, Ark.	White	1.56	0.25	2.76	0.74	1.56	1.93	2.13	0.75	0.00	1.87	13.55
Newport, Ark.	do	1.45	0.47	2.66	1.27	2.20	2.65	1.66	0.36	0.02	2.82	15.56
Clarendon, Ark.	do	1.69	1.65	3.77	2.83	1.73	3.02	1.79	0.10	Trace.	1.58	18.16

Red Drainage Basin.

Arthur City, Tex.	Red	2.60	0.00	0.40	0.00	1.30	3.60	0.50	1.20	2.80	0.80	13.20
Shreveport, La.	do	2.36	1.24	1.37	0.24	3.23	4.38	2.66	0.83	0.32	3.80	20.43
Alexandria, La.	do	1.66	3.31	4.06	3.35	3.08	1.72	1.70	1.64	0.15	3.33	24.00
Camden, Ark.	Ouachita	2.68	1.11	2.48	1.09	2.09	3.42	2.26	0.36	0.40	4.87	20.76
Monroe, La.	do	3.36	2.46	2.76	0.00	2.62	4.40	0.96	0.40	1.29	4.86	23.11
Melville, La.	Atchafalaya	1.85	0.20	0.25	0.05	3.95	4.60	0.00	0.80	0.00	4.05	15.75

Lower Mississippi Drainage Basin.

New Madrid, Mo.	Mississippi	0.90	0.90	1.60	2.92	1.54	4.70	1.80	0.73	0.19	1.60	16.88
Memphis, Tenn.	do	1.25	1.36	3.52	2.30	0.60	0.51	2.43	0.06	Trace.	0.75	12.78
Marked Tree, Ark.	St. Francis	0.82	1.74	3.95	2.48	1.07	5.35	1.64	0.40	Trace.	1.91	19.36
Helena, Ark.	Mississippi	1.36	2.12	3.62	0.96	0.74	2.10	2.02	0.50	Trace.	2.58	16.00
Arkansas City, Ark.	do	1.90	3.33	3.02	0.10	0.91	2.78	2.15	0.22	0.49	2.47	17.37
Greenville, Miss.	do	2.66	4.61	2.30	0.40	1.03	4.65	1.65	0.33	0.76	2.96	21.35
Yazoo City, Miss.	Yazoo	4.74	3.53	2.90	0.31	0.97	2.93	2.16	1.14	0.47	1.93	21.08
Vicksburg, Miss.	Mississippi	6.14	3.45	2.24	0.40	1.62	2.19	1.08	1.20	0.60	2.14	21.06
Natchez, Miss.	do	1.98	3.34	2.18	0.60	2.31	2.26	2.09	2.38	0.27	0.43	17.84
Baton Rouge, La.	do	2.30	1.90	2.40	0.30	3.90	1.43	1.33	0.08	0.15	0.32	14.11
Donaldsonville, La.	do	2.28	1.05	1.40	0.52	2.10	2.50	1.61	Trace.	0.25	2.56	14.27
New Orleans, La.	do	1.10	2.07	0.78	0 95	2.47	2.18	0.67	0.00	0.57	2.62	13.41

An inspection of this table will show that heavy rains were rather general in most basins in the second and third week of March. The response of both the Ohio and Tennessee was almost immediate. See the hydrograph for Cincinnati, Figure 1. Heavy rains continued in the Ohio Basin during the first half of April causing two distinct crests in the Ohio in that month.

In general the discharge of the Mississippi at and below St. Louis, Mo., rose steadily during March and the great volume of water passed down stream as a long drawn-out wave as shown by the hydrographs in Figure 1.

Run-off.—Discharge measurements for the 1922 flood are not yet available to the Weather Bureau. The author has worked out, however, tentative discharge figures based upon the average ratio of discharge to precipitation as given by Morrill in *Weather Bureau Bulletin E*, Table XIV, page 27. The values in that table were those assumed by Humphreys and Abbott and by Greenleaf and are as follows:

TABLE 3.—*Ratio of discharge to precipitation.*

Basin.	Ratio.	Basin.	Ratio.
Ohio	0.30	Red	0.22
Upper Mississippi	0.28	Lower Mississippi	0.52
Missouri	0.15		
Arkansas	0.18	Total	0.25

Using the values given in the above table the rainfall and run-off for seven great floods has been computed. Only the figures for the 1922 flood are given in this abstract; they follow as Table 4 below.

TABLE 4.—*Precipitation in inches over drainage basins and discharge in millions of cubic yards for 1922 flood.*

Drainage basin.	1922							
	February.		March.		April.		Total.	
	Precipitation.	Discharge.	Precipitation.	Discharge.	Precipitation.	Discharge.	Precipitation.	Discharge.
Ohio	0.79	15,264	1.75	38,482	1.25	27,369	3.79	81,115
Upper Mississippi	0.27	5,711	0.51	10,708	0.72	14,991	1.50	31,410
Lower Mississippi	0.40	15,083	0.69	26,197	0.30	11,378	1.39	52,658
Missouri	0.34	5,156	1.25	13,809	1.34	20,324	2.93	39,289
Arkansas	0.34	4,837	1.02	14,513	0.92	13,032	2.28	32,412
Red	0.42	6,474	0.76	10,755	0.69	10,733	1.87	27,962
Total	2.47	52,525	5.98	114,464	5.22	98,157	13.67	256,146
Ratio		0.27		0.25		0.23		0.25

The discharges are given in millions of cubic yards and were obtained from the ratios given in Table 4. The author concedes that his discharge values are based upon estimates of high authority rather than actual measurements, but nevertheless they serve as a basis of comparison with previous floods. The drainage areas used in the computations and the ratio of the different basins to the whole are shown in Table 5 below.

TABLE 5.—*Drainage areas used in computations and ratios to entire basin.*

Basin.	Area in square miles.	Ratio to whole.
Ohio	203,900	24
Upper Mississippi	148,150	17
Lower Mississippi	60,300	7
Missouri	205,750	24
Arkansas	145,000	17
Red	90,000	11
Total	853,100	100

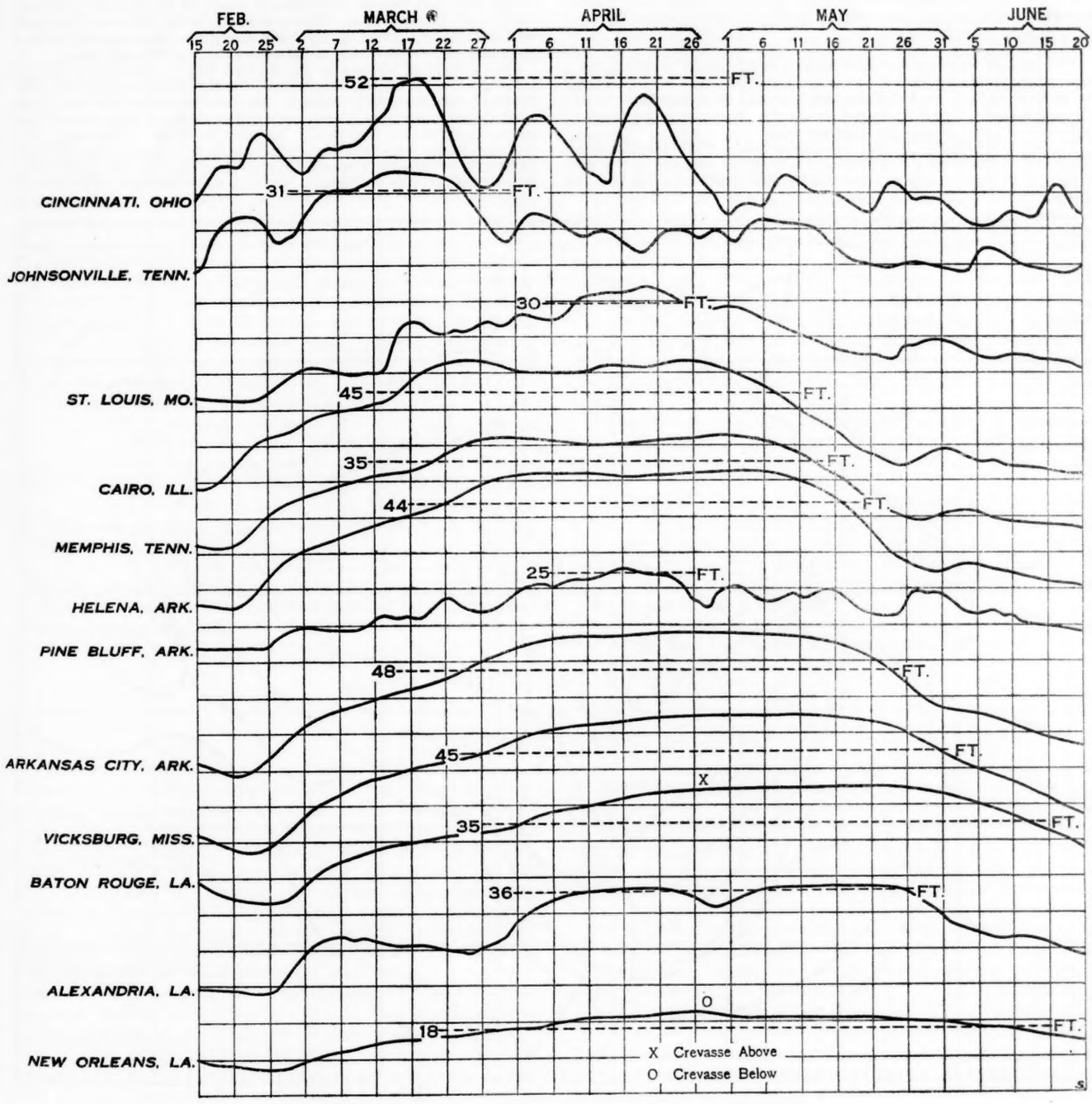

FIG. 1.—Hydrographs for selected stations, lower Mississippi River flood of 1922.

COMPUTATION OF RAINFALL FOR EACH BASIN.

Charts are given showing the distribution of precipitation for the months January to April, both inclusive, but in computing the total precipitation for the flood the months of February, March, and April only were used. The procedure followed in obtaining the totals for the several basins is given in the author's own words, as follows:

The rainfall for each drainage basin was computed according to a method suggested by Marvin and is as follows: Monthly data for a large number of stations were charted and isohyetal lines carefully drawn. These lines were then traced upon sheets of cross-section paper together with the outlines of the six drainage areas.

The isohyets divide the drainage basins into various irregular small subareas, over which the precipitation may be assumed to be uniform and of an amount represented by the mean between the two adjacent isohyetals. Therefore the number of squares in each subarea was counted. This number was then multiplied by the average precipitation for the subarea in question and the product divided by the sum of the counts for all the subareas, which latter, of course, is the number of squares in the whole drainage basin being studied. Finally, the sum of the quotients found in the above manner gives the depth of precipitation which, spread uniformly over the whole basin, would represent the same amount of water as fell in the irregularly distributed precipitation. This procedure, while laborious, was well worth the time consumed, and it is thought to have accomplished a more accurate presentation of data than was possible otherwise.

The number of squares in the subarea was limited always by the boundary lines of the watershed, except in the extreme upper Arkansas, Missouri, and Mississippi valleys. In these territories the winter and spring precipitation is invariably small, mostly in the form of light snow, contributing practically nothing to flood conditions. The drainage basins were therefore cut off for these regions by an arbitrary straight line running through Omaha, as shown by the heavy dash line on the left side of Figure 2, which is reproduced.

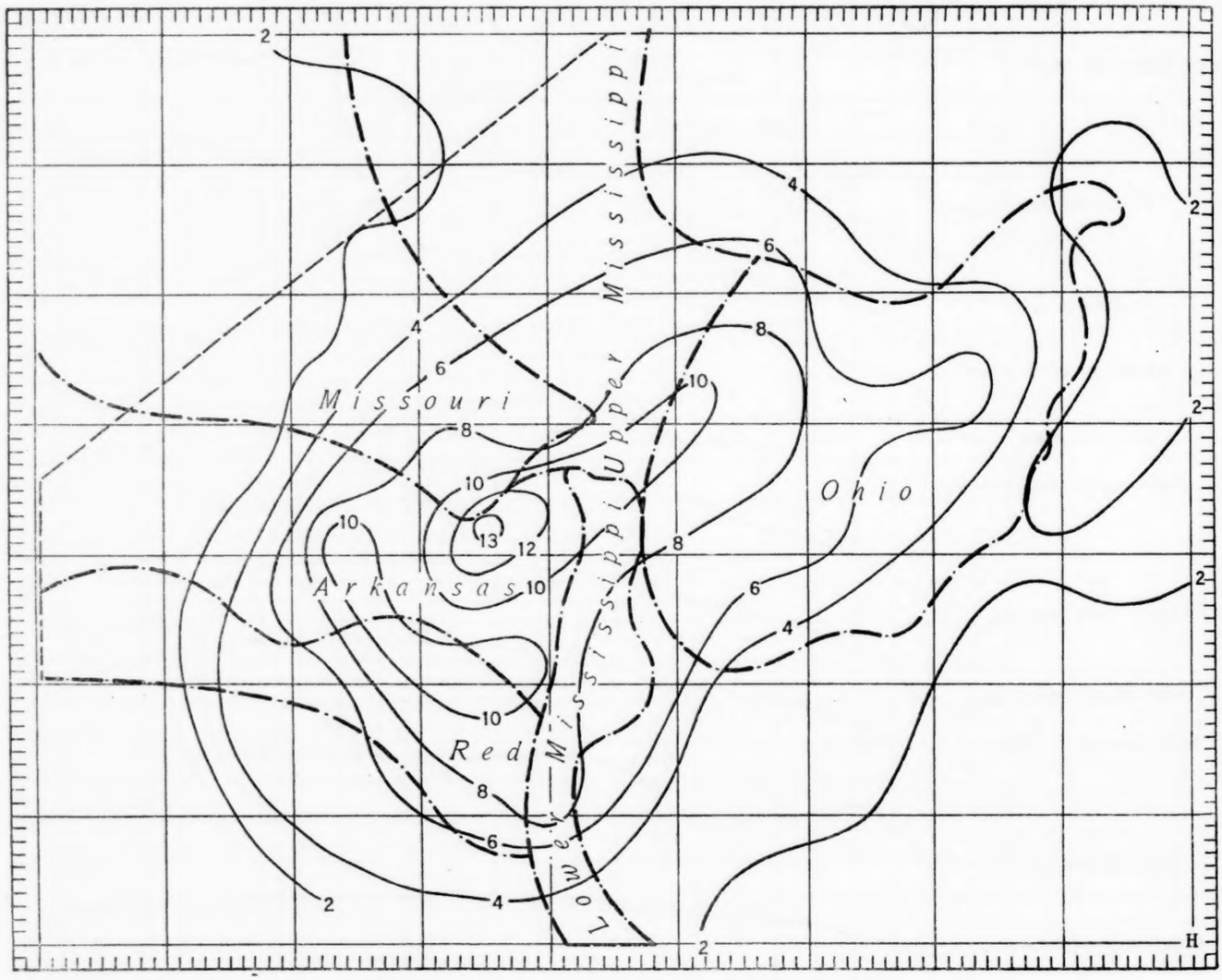

FIG. 2.—Illustration of method of determination of amounts of precipitation.

THE AMAZON RIVER FLOOD.

By DR. HAGMANN.

[Extract translated from *Revista Mensal de Meteorologia*, Rio de Janeiro, Brazil, May, 1922.]

The flood of this year [1921] in the Amazon River was extraordinarily great. The water reached a height beyond that of previous years.

The Amazon River, as a rule, rises until the end of the first fortnight of the month of June. "Saint Antonio is at the head of the water," says the Indian. * * * The flood of the year, 1921, was 20 cm. greater than that of 1918, which old inhabitants thought to have equaled that of 1859.

Laborious, but very interesting, was the work of computing the superficial total of the overflowed areas in the valley of the Amazon in order to have some idea at least of the enormous quantity of water that would be necessary to produce a flood of such proportions.

I am personally convinced that the enormous floods that have recurred in these last years are not so entirely the result of the extraordinary precipitation in the high regions of the Amazon River, as a study of the reports received from the commandants of certain affluents of the Amazon do not show a greater quantity of water. I am of the opinion that the reason of the great floods may lie in part in the constrictions in the mouth of the Amazon. On the front sides of the islands of Bailique, Cavianna, Mexiana, and Marajo is the celebrated bank of sand, "Santa Rosa," many kilometers in width and length, where the water is barely 6 meters in depth. These channels are narrow, tortuous, and liable to constant shifting, and do not permit the entrance of trans-Atlantic ships.

I lived for two and one-half years on the island of Mexiana, and for this reason I know the mouth of the Amazon very well. The mouth extends from Mexiana to Belem, three days' sail by boat, to say nothing of the danger from the wretched climate.

Islands form and disappear as the waves scour and carry the sand loosened from the banks. Points of islands with great trees from the virgin forests fall with the constant erosion of the water, always agitating and dislodging from the outer banks masses of sand that constantly increase, the first foothold for the growth of grass and rushes, and later for the bushes and trees whose seeds were floating around. The dark gray color of the water shows conclusively the quantity of sediment that it carries.

On this account the opinion can not be rejected that in general the mouths of the Amazon have become constricted, leaving not more than sufficient opening for the waters in winter time, thus causing in part the enormous floods of the lower Amazon.

A plotting of the pluviometric data for the stations along the Amazon would contribute much to the solution of this problem, so interesting in connection with the hydrographic knowledge of the "river sea."

Discussion by the director.—The director expects to visit various places in the States of Para and Amazon, the flood and rainfall stations, as soon as he has finished a hasty study of the proposition of Doctor Hagmann. The installation of these posts will be completed by Inspector Avellar Figueiredo, as soon as he has completed his mission in some of the Northern States.

An interesting feature of Doctor Hagmann's presentation is his belief in the possibility that the sedimentation in the mouth of the Amazon River causes some of its floods.

It would be advisable to verify this assumption which, a priori, appears to be hardly acceptable, because the tide and the strong-running equatorial on the coast would be sufficiently strong to impede the excessive formation of banks, or bars, at the mouth to such an extent as to retard the passage of flood waters.

A hydrometrical chart would probably better reveal the solution of this interesting problem.—*H. C. F.*

FROST-FIGHTING IN THE PECOS VALLEY.

CLEVE HALLENBECK, Meteorologist.

[Weather Bureau Office, Roswell, N. Mex., December 7, 1922.]

Fruit-growing in the Pecos Valley of New Mexico is an attractive proposition or an extra-hazardous one, depending upon the point of view. The quality of the fruit is unexcelled, the abundant sunshine imparts a coloring not attained by the same varieties in other districts, and the leading varieties ripen at a time when the large markets are empty of apples. The Jonathan apples of the Pecos Valley are well known in England. A noted author declared that the discriminating taste of man now demands "caviar from Russia, olives from Italy, apples from New Mexico," etc.

On the other hand, there probably is no other fruit-growing district in the United States that is as liable to spring freezes as is the Pecos Valley. On an average, two freezes occur each spring after the apples are susceptible to injury therefrom, and in only 3 years in the last 18 have unprotected orchards borne full crops. On a 10-year average, the unprotected orchard is only 45 per cent efficient, and this 45 per cent practically equals the current upkeep, taxes, and interest on the investment, leaving no profit to the owner.

During the past seven years there has been a decided resumption of orchard heating in this district. This is in small part due to the fact that for eight years no spring freeze has arrived unheralded, and that such can occur in the future is well-nigh impossible. But the principal cause of this revival is due to the fact that in the past 10 years unprotected orchards have borne but one full crop, with six total failures, while protected orchards have borne eight full crops in that time. It is now the unanimous opinion of the leading fruit growers that apples can be saved every year, for all the veteran orchardists brought their crops safely through the record-breaking freeze of April 19, 1922; and in 1920 two of them, who did not know when they were whipped, saved full crops against minimum temperatures of 15° and 16°.

The object lesson was clear. Consequently, in 1922 hardly an orchard of commercial size could be found that was not equipped for frost fighting. Every serviceable heater in the valley was impressed into service, several carloads of additional heaters were shipped in, and a few procrastinating orchardists, unable to secure heaters in time, distributed baled weeds and straw through their orchards, to be burned as occasion required.

Frost fighting.—Six or seven acres of orchard is about all that one man can properly look after. In small orchards of 30 acres or less the owner and his family, with a hired man or two, are usually sufficient to handle the situation, but in the larger orchard a "frost-fighting squad" is required, and necessarily it must be recruited principally from the town population. The members of any one squad, therefore, are likely to be well scattered

over town, and some arrangement must be made for assembling these men quickly and certainly and for getting them out to the orchard. The following case, which is fairly illustrative, with slight modification, of all, will show the organization and handling of the frost fighters.

The owner of an 80-acre peach orchard employed 15 men (including himself); these were divided into three groups of 5 each, one man in each group acting as foreman and furnishing an automobile for transporting himself and his four assistants to the orchard. The orchard was divided into 12 plots, one to the man, and each man knew exactly where his plot was, as these were marked by numbered boards. In each plot was a thermometer, and the three foremen (one of whom was the owner) did nothing in the orchard except watch these thermometers and superintend the heating when such became necessary. By an ingenious arrangement of the heaters, one-fifth, two-fifths, or four-fifths of them could be lighted, and in each case the lighted heaters would be uniformly distributed. The remaining one-fifth were to serve as a reserve. In addition, two truck loads of filled heaters were kept ready as a "mobile reserve."

The orchardist, who received the warnings direct from the Weather Bureau office, communicated them to each man of his squad, but he also arranged, in the event that emergency night warnings should issue, to call only his two foremen and his own group, leaving the foremen to rouse their own men; in this way some valuable time could be saved.

This method, with some slight variation, was adopted by all the leading orchardists.

Inasmuch as the fruit crop represents the chief source of wealth in this district, recruits for orchard squads were plentiful, and most of them served without compensation. In addition, the local chamber of commerce maintained a list of men willing to serve on short notice, to fill unexpected vacancies in the frost-fighting squads. The morning after a freeze found smoke-begrimed business and professional men, clerks, and laborers straggling into town by automobile loads.

Dissemination of warnings.—It is impossible for this office to telephone warnings to each fruit grower, of which there are 113 within the free telephone limits of Roswell and probably as many more in the lower valley districts of Dexter, Hagerman, and Artesia. Prior to 1922, warnings were given only to the seven fruit-frost observers, the four districts—Berrendos, Fairview, South Springs, and Hondo—being within the free telephone limits. But this put a hardship upon some of the observers, who were serving without pay; particularly the observer at South Springs, who had nearly 50 orchardists in his district, and to notify all of them, as he faithfully did, consumed much time.

In 1922 a different plan was adopted. With but two exceptions, all the orchardists within the free telephone limits are on "party" telephone lines. Warnings were given to one individual on each line, with the understanding that he was to communicate it to the remaining subscribers on his line. Volunteers for this service were called for, and immediately most of the orchardists volunteered; each wanted to receive warnings first hand. One was selected for each line, with an alternate in case the first one could not be reached. The names of these "line representatives" were published, so that each orchardist would know on whom to depend for warnings. In this way all the fruit growers around Roswell could be reached with 21 telephone calls.

Similar arrangements were made by the fruit-frost observers in the Dexter-Hagerman and Artesia districts, to whom all warnings were communicated directly from this office.

In addition, it was understood that should emergency night warnings be issued, they would be communicated by this office only to the fruit-frost observers, they in turn to give them to each "line representative" in their respective districts, by whom they would be given to the individual orchardists. In this way, a warning could be spread throughout the valley in half an hour.

Desirous of testing the efficiency of the latter arrangement, a night was selected when minimum temperatures close to freezing were expected. No forenoon or evening warnings were issued. At 2:30 a. m. the four observers within the free telephone limits were called and told to prepare their districts for prompt action. Before the fourth one had been roused automobiles were heard leaving Roswell, and within 15 minutes more automobiles were heard in every direction. After 30 more minutes silence again reigned. The celerity with which the alarm spread was remarkable. The temperature on this occasion hovered around 31° and 32° for two hours, and since the orchardists stood guard from 3 a. m. until sunrise, in the cold, it was not thought advisable to inform them that they had been made the victims of an experiment. Besides, their honest expressions of gratitude for this "watchfulness" of the Weather Bureau office were pleasant to hear.

Frost forecasting.—In the Pecos Valley, and presumably in all other irrigated regions of the West, temperature forecasting is beset with difficulties not encountered in eastern districts. It appears that the blossoming time of fruit trees depends upon the mean temperature rather than upon the mean maximum or minimum, in so far as this activity is governed by temperature. The average time of blossoming of apples is the same in the Pecos Valley as in the more humid eastern districts having the same mean temperature. But on account of the large daily range of temperature here (normally 42° in clear weather in the country) apples begin blossoming when the normal daily minimum temperature is but 2° above freezing, and are in full blossom when the normal minimum is only 6° or 7° above freezing. Consequently any condition that can depress the temperature a few degrees below the normal is likely to cause damage to the fruit.

Such depression can easily be produced by a clear night following a cloudy day. Unless checked by condensation or by an inflow of warm air the normal radiational fall of temperature will occur at night regardless of how low the temperature may be in the evening. Many of the cold waves occurring at Roswell, including nearly all that have occurred without warning, were due to a cloudy day followed by a clear night. The average dew point is some 16° below the average minimum temperature, and sometimes is 40° or more below the minimum. Consequently there rarely is any condensation of dew or frost to counteract radiational cooling. Unless the humidity is quite high, evening cooling in the spring is the signal for frost warnings. Actual frost, of course, rarely occurs, even in midwinter.

Hygrometric formulæ, so far as this district is concerned, are absolutely worthless in calculating minimum temperatures. This is due to the great variability of the dew point, which may change as much as 20° or 25° over night. A 12-hour fall in dew point of 65° occurred on one date in the spring of 1918. A shift of the wind nearly always is followed by a considerable change in the dew point; a shift from southeast to southwest can lower

it 20° in three hours. This variability is greater in spring than in any other season. In addition, in still weather there is an area of relatively high humidity over the farming region, due to evaporation from liberally irrigated land. In the spring irrigation is general and is almost at its peak, while the surrounding prairies are, normally, at their dryest. It is the same as though about three counties from the Ohio Valley region were transplanted to the arid West; the Pecos Valley is, in fact, a long oasis in a desert. A moderate wind serves to sweep this evaporated moisture away, and the dew point at any hour is a very unreliable indication of what it may be a few hours later.

On account of the moister soil, which normally is covered with growing vegetation, and the higher humidity, over the farming region, radiational cooling is less than over the bare, dry prairie. The difference, in spring, may amount to as much as 8°, and any inflow of air into the valley from the surrounding prairie at that time will be attended by a rather sharp fall in temperature. Such inflow often seems to be in the form of quite limited streams, which may cause large differences in the minimum temperatures recorded at different points. An example of this occurred in connection with the freeze of April 19, 1922, when the minimum temperature was exactly forecast for three substations and within 1° for two more, but with errors of 4° and 7° for the remaining two stations. At one of these stations the observer reported that the fall was caused by "a shift of the wind to southwest," and at the other the fall "attended a shift of the wind from southeast to west." The wind was very light throughout. These conditions can not be forecast, and all the orchardist can do is to have a reserve of heaters ready to meet the emergency when it arrives. The fall of temperature is rarely so abrupt or so large that a watchful frost fighter can not successfully combat it with reserves. Then there is air drainage down the Pecos Valley, and secondary drainage eastward down the tributary valleys, which may cause sharp falls in temperature of as much as 12°. Since this normally occurs on clear, still nights in spring, it usually can be foreseen and allowed for in calculating the minimum temperature. It is very treacherous, however. It moves slowly, and the change in wind direction may occur without being noticed. The drop in temperature often is very abrupt. In addition, this down-valley flow of cold air sometimes arrives well after sunrise. Fruit has been damaged in this district by sudden drops in temperature occurring 1 and 1.5 hours after sunrise with a clear sky.

Then there is the topographic factor to be considered. A wind from any direction whatever, is moving either up or down slope, and the resulting effect upon the temperature may be quite noticeable. It also is necessary to distinguish between a general flow of air and a purely local wind. For example, a westerly wind that is a part of a cyclonic circulation will materially retard night cooling and may even cause a substantial rise, while a westerly wind that is merely cooled air draining to lower levels will be attended by a large fall in temperature.

On account of the pronounced morning temperature inversion characteristic of this and other districts of the semiarid West, and which is normally most pronounced in spring, a very moderate stirring of the air in the early morning following a clear, still night will raise the temperature materially. Many a carefully prepared minimum temperature forecast has thus been nullified by an early morning wind.

From what has been said, it is obvious that the calculating of minimum temperatures from hygrometric formulæ or from the evening radiational cooling is a very uncertain proposition. It also is clear that the probable direction and velocity of the wind is of as much importance to the forecaster as to the orchardist.

It has been found that the most reliable temperature forecasts are those made from the weather map, local influences being given due weight. But even here, the sparsity of reporting stations, and the entire absence of reports from the south (Mexico) inject a very large element of uncertainty into the forecasts. There are but three other Weather Bureau stations within a 300-mile radius of Roswell, as compared to 20 to 40 stations in similar areas in the eastern half of the United States, although within a 300-mile radius of Roswell can be found nearly every kind of climate found in North America. One needs a great deal of intuition to make satisfactory forecasts under such a handicap. A former district forecaster informed the writer that "Good forecasts are based upon general conditions, local influences and intuition, and of these intuition is the greatest."

Fortunately, the probable minimum temperature is of secondary importance to the orchardists, and is of very little interest to those who are equipped to meet any temperature that might occur. Next to the information that a freeze is impending, they consider the direction and velocity of the wind of paramount importance. Following a forenoon warning of freezing for the following night, the orchardist and his helpers begin shifting heaters to reinforce the windward side, if such shift be necessary. Next in importance is the hour at which critical temperatures are expected. We formerly allowed a margin of safety of 1 to 3 hours until we learned that the orchardists themselves were allowing a similar margin, after which we gave them the actual hour, as nearly as could be calculated. If freezing was expected for, say, 4 a. m., that hour was named in the forecast, but the orchardists were ready for action at 2 a. m., or even earlier, and sometimes this precaution was justified.

The freeze of April 19, 1922.—A large percentage of the fruit growers in this district had their first experience in orchard heating in the spring of 1922, and with few exceptions the experience was disastrous. Their heaters were too few and far between for the freeze of April 19, which, considering the state of the fruit, was the most severe freeze of record here. They were equipped for the freeze that normally occurs, but not for the one that *could* occur. Even some of the more experienced ones lost heavily, but the few old veterans in orchard heating brought their crops through safely.

Nevertheless, none of them are discouraged, and this commendable attitude is due to the experience of one orchardist, himself a novice, whose performance deserves mention in view of the fact that it was of incalculable value to the fruit industry in the Pecos Valley. This man was Dr. A. D. Crile, former president of the New Mexico Agricultural College, whose frost-fighting squad has been described herein. Before equipping his orchard with heaters, he spent most of one afternoon in the Weather Bureau office, going thoroughly into the records of spring freezes. Incidentally, taking the record minimum temperatures (rural) of 15 on April 4 and 26 on May 7, he calculated the *possible* minima for each intervening date. For April 20 he calculated a possible minimum of 21° (and a record-breaking minimum of 21° occurred in his district on April 19). Accordingly he equipped his orchard with sufficient heaters to raise the

temperature 10°, securing, at our suggestion, the smallest type of heater obtainable. Eighty of these were placed to the acre. During the frost season he called in person at the Weather Bureau office every time frost warnings were issued. Consequently, while his orchard was completely isolated and surrounded by bare prairie, with the additional handicap of being in the coldest spot in the entire valley on that night, he successfully fought the freeze of April 19 with 80 per cent of his heaters in action. Three days later we personally inspected his orchard at his request, and found no damaged peaches.

It always had been taken for granted that peaches could not be protected in this district, but when this man not only saved the crop but did it under two heavy handicaps, he proved beyond argument that every peach and apple in the valley could have been saved. Consequently, those who lost are preparing to double the number of heaters in their orchards, or, where unable to do this immediately, to concentrate their heaters upon a much smaller acreage. Instead of receiving a blow, orchard heating here has received an impetus. Even in the Grande Valley, with which this station is not concerned, orchardists, hearing of Doctor Crile's remarkable performance, are preparing to protect their extensive pear orchards next spring.

Orchard heaters and thermometers.—Small heaters were shown to be decidedly more effective, cost for cost, than large ones. "Small heaters and plenty of them" is the advice given by the veterans to the beginners. An ideal orchard heating system would be one that warmed a continuous layer of air next to the ground. "Small heaters and pelnty of them" comes nearest to the ideal condition. One orchardist, who has saved a full crop of apples each spring for the last 12 years, declared that, while he is using the smallest, lowest heater obtainable, he would discard his entire equipment if he could secure a heater that is still smaller or lower.

At the suggestion of the writer, seconded by the county agricultural agent, a number of fruit growers last spring tried the experiment of placing the heaters directly under the trees. The results were so gratifying that in the future nearly all the orchards equipped with small, low heaters will be protected in this way. Portions of lower branches that were completely blackened with smoke suffered no damage and bore unblemished fruit

The local farm bureau organization is preparing to publish working drawings of one of our model instrument shelters and distribute them to all fruit growers in the district.

A CLIMATOLOGICAL CALENDAR FOR COLUMBIA, MO.[1]

By GEORGE REEDER, Meteorologist.

The writer has compiled the mean minimum temperature for Columbia, Mo., for each day of the year for use in class work and as forming the basis of short informal talks before commercial clubs and organizations. He has found so many interesting and instructive applications of these data that it seems desirable to outline the plan followed in the belief that his fellow workers will be benefited thereby.

The minimum temperature was chosen since it is largely the controlling factor in the vegetable world. After computing the means for the 32 years of record, they were assembled in groups. In forming the groups all temperatures within a range of 5° were put in the same group, thus all values between 15° and 20° were put in one group, all those between 21° and 25° in the next and so on up to the highest group which has a mean of 65.7°. As illustrating the time limits and the mean values of the different groups the table below is given:

TABLE 1.—*Mean minimum temperature, Columbia, Mo., by groups of significant dates.*

Inclusive dates.	Mean temperature.	Significant dates.
Feb. 11–22	22.4	The beginning of the annual upward march.
Feb. 23–Mar. 7	26.1	
Mar. 8–17	31.3	Mean minimum, Mar. 13, 33°; time to sow oats.
Mar. 18–22	35.0	
Mar. 23–Apr. 4	37.9	Mean minimum, Mar. 25, 38°; time to plant Irish potatoes.
Apr. 5–17	41.4	Mean minimum, Apr. 15, 42°; corn planting begins; Apr. 21, peaches and apples in blossom.
Apr. 18–May 2	47.5	
May 3–18	51.3	
May 19–June 2	57.2	
June 3–23	63.2	June 3, mean minimum, 60°; summer begins.
June 24–Aug. 20	65.7	July 9–11, three consecutive cooler nights; July 13–17, 5 consecutive warm nights.
Aug. 21–Sept. 11	61.0	Corresponds with period June 3–23, but in reverse order.
Sept. 12–25	56.4	
Sept. 26–Oct. 5	51.7	Time to sow winter wheat.
Oct. 6–18	46.8	
Oct. 19–26	42.5	
Oct. 27–Nov. 10	38.1	
Nov. 11–27	31.8	
Nov. 28–Dec. 11	26.4	
Dec. 12–Jan. 29	21.6	Jan. 12–13, two coldest days of winter; mean minimum, 14° and 16°, respectively.
Jan. 30–Feb. 10	17.8	The coldest 12-day period.

After assembling the daily means in groups and computing the group means it was found that the period from January 30 to February 10, inclusive, gave the lowest group mean, viz. 17.8°. That period therefore served as the starting point for the upward march of the group means. The date February 11 has therefore received the initial number in the consecutive series of 366 days.

Many interesting facts can be drawn from the series of means, as, for example, the dates of planting staple garden vegetables, the sowing of grains, etc. Other interesting features from a climatological standpoint are the lowest daily means for five consecutive days—the time of the greatest consecutive severe cold of the winter falls on February 1 to 5, although the absolute minimum for the year falls on January 12. A week later, January 19–23, is the date of the so-called "January thaw," during which time the mean minimum rises to 28° on January 20, immediately dropping to 23° on the 21st. Is there any relation between these two events? Many other interesting comparisons may be made.

[1] Condensed from the original manuscript.

NOTES, ABSTRACTS, AND REVIEWS.

Henry F. Alciatore, 1866–1923.

Henry F. Alciatore, a member of the well-known New Orleans family of that name, died in that city on February 2, 1923.

Mr. Alciatore was for many years a valued official of the Weather Bureau. He had been in poor health for several years and was forced to give up active work about three years ago. During the 34 years of his connection with the Government service, he filled many important assignments, some of which were at New Orleans, La., Galveston, Tex.; San Francisco, Calif.; Portland, Oreg.; Reno, Nev.; and San Diego, Calif.

Mr. Alciatore will be remembered as a gentleman of most pleasing personality, thoroughly loyal to the service in which he spent the greater part of his life and to which he contributed of his knowledge and experience.

He is survived by his widow, four brothers, a sister, and numerous cousins, nephews, and nieces.—*A. J. H.*

THE COURSE OF THE GULF STREAM IN 1919–21, AS SHOWN BY DRIFT BOTTLES.

By Prof. JAMES W. MAVOR.

[Abstracted from *Science*, January 5, 1923.]

Drift bottle experiments have been conducted by the biological board of Canada for some time past. The results have appeared in various numbers of *Science* for 1920, 1921, and 1922; also in *Proceedings American Fisheries Society*, 1920, page 334.

In the issue of *Science* above mentioned an account is given of the finding of four bottles which crossed the Atlantic after being set adrift in the Bay of Fundy in August, 1919. The record of finding follows:

No. 198. Azores, island of Flores, August 8, 1920.
No. 230. Orkney Islands, island of Papa Westray, January 21, 1921.
No. 98. Great Britain, Dyffryn, North Wales, March 25, 1921.
No. 129. Norway, 2 miles from land at the Bohle-Walstation, Soro, Westfinmark, July 16, 1921.

The distances these bottles must have traveled measured along the shortest courses which they could have taken are approximately 2,000, 2,800, 2,900, and 3,800 geographical miles. The corresponding time which the bottles were "out" are 12, 17, 19, and 23 months, respectively. This close correspondence between the distance traveled and the time the bottles were "out" indicates that they were picked up relatively soon after reaching the coast. If this assumption is correct, the average rates at which the bottles traveled across the Atlantic were 5.8, 5.4, 5.1, and 5.5 geographical miles per day.—*A. J. H.*

A PERIOD OF WARM WINTERS IN EUROPE.

By C. E. P. BROOKS.

[Excerpts from *Meteorological Magazine*, September, 1922, 57: 203–205, map.]

Among the most interesting problems of meteorology are the local changes of climate extending over years or even decades. Their causes are usually obscure, and often the most that can be said is that they are secondary effects of long-period fluctuations in the circulation of the earth's atmosphere. An example which has recently come to light is the abnormal winter warmth of central Europe during the decade 1911 to 1920.

The differences between the mean temperatures for January, February, and December for the years 1911 to 1920, and the long-period averages for the several stations (usually covering the years 1851–1910) show that the maximum effect, exceeding 3° F., extends in a long belt from Denmark to the Balkan Peninsula * * *. From the central isanomaly of 3° F. the excess falls off rapidly in all directions except the west * * *. On the Atlantic seaboard the winters of the decade in question have been slightly colder than the normal * * *.

We have here an appreciable change of climate which appears to be analogous to the Brückner cycle, but not identical with it because the Brückner cycle should give low instead of high temperatures during the past decade. A tentative explanation connects it with the general decrease of sunspot numbers since the nineteenth century. Sunspot numbers are an index of the intensity of the solar radiation which governs the strength of the earth's atmospheric circulation. Now a by-product of this circulation is the gradient between the subtropical Atlantic anticyclone and the Icelandic minimum. (The mean gradient between Iceland and Lisbon has been decreased from 21.2 mb. to 19.5 mb. during the period 1911–1918.) At first sight this should mean decreased southwesterly winds from the Atlantic and consequently lower winter temperatures over central Europe but it happens that the winter weather in this region is mainly anticyclonic and is only slightly affected by the Atlantic pressure gradient. its severity is, however, very much lessened when frequent depressions break through, and this happens most readily when the atmospheric circulation is weakest and the oceans are, accordingly, relatively cold.

When the air circulation is strong, that of the ocean is strong also, and in temperate latitudes the waters are highly warmed so that depressions follow the coasts and the continental anticyclones escape their influence.

This hypothesis is only tentative, but it agrees with Brückner's conclusions based on his studies of the 35-year cycle,[1] and also with those based on the study of the secular variation of the annual means of pressure and temperature since 1870.[2]

RELATIVE SUNSPOT NUMBERS, 1920–1922.

Below are given the relative numbers of sun spots as observed and published by A. Wolfer, Zurich, Switzerland. The numbers are a continuation of those printed in this REVIEW, August, 1920, page 460.—*A. J. H.*

TABLE 1.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.	Annual.
1920.....	57.3	50.9	71.9	14.3	33.7	38.8	26.5	18.6	38.7	48.8	21.6	39.9	38.7
1921.....	28.8	27.6	27.5	30.5	22.3	34.5	42.4	20.8	16.7	16.1	13.4	15.7	24.7
1922.....	10.2	27.9	66.0	11.4	7.7	5.8	9.7	5.3	5.2	8.1	6.7	18.7	14.7

[1] *Klimaschwankungen seit 1700.* Wein, 1890.
[2] Brooks, C. E. P.: The Secular Variation of Climate, *Geog. Rev.*, New York, 11, 1921, p. 120.

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SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JANUARY, 1923.

HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations.

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, **48**:225, and a note in the REVIEW for November, 1922, **50**:595.

From Table 1 it is seen that direct solar radiation intensities averaged below the normal values for January at Washington and Madison, and close to normal at Lincoln. There were few days on which measurements could be made at the two latter stations, however.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged below the January normal at all three stations, although at Lincoln there was more than the average radiation after the first week.

Skylight polarization measurements were obtained at Washington on the 11th only, and gave a percentage of polarization of 66 per cent. At Madison the ground was covered with snow throughout the month, and no measurements were obtained.

TABLE 1.—*Solar radiation intensities during January, 1923.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.										
	8a. m.	77.8°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th mer. time.	Air mass.									Local mean solar time.
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Jan. 2	3.30	0.65	0.81	0.95	1.19						3.45
4	3.63	0.50	0.62	0.77							3.30
11	2.06	0.67	0.79	0.94							2.36
12	4.17	0.58	0.73	0.90	1.10			1.04	0.93	0.82	3.45
13	2.16				1.08			0.92	0.71	0.52	2.16
17	1.37	0.82	0.96	1.10							1.52
Means		0.64	0.78	0.93	1.12			(0.98)	(0.82)	(0.67)	
Departures		−0.12	−0.09	−0.08	−0.10			−0.13	−0.13	−0.15	

Madison, Wis.

Jan. 3	2.62		1.05	1.18							3.30
10	3.15	0.95	1.07								3.63
15	2.74		1.12	1.23							2.87
16	3.00			1.25							2.74
22	2.16	0.95	1.10	1.16	1.30	1.41					2.36
Means		(0.95)	1.08	1.20	(1.30)						
Departures		±0.00	−0.01	−0.05	−0.06						

Lincoln, Nebr.

Jan. 4	2.49	0.87									3.15
10	1.12		0.88								1.52
11	2.36		0.95	1.22	1.44			1.24	1.07	0.92	2.49
15	2.49	0.89	0.97							0.90	3.00
28	2.74				1.36			1.13	1.00	0.78	2.49
Means		(0.88)	0.93	(1.22)	(1.40)			(1.18)	(1.04)	0.87	
Departures		−0.03	−0.09	+0.06	+0.05			−0.01	±0.00	−0.05	

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning—	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 1	119	105	120	−38	−37	−68	−267	−257	−478
8	147	109	212	−16	−43	+16	−378	−559	−368
15	136	171	230	−36	+ 5	+23	−628	−527	−208
22	110	144	206	−74	−42	−19	−1,145	−824	−341

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

By C. G. ABBOT, Assistant Secretary.

[Smithsonian Institution, Washington, Feb. 28, 1923.]

In continuation of preceding publications, the following table contains further results for the solar constant of radiation obtained at Montezuma, near Calama, Chile. The values of ρ/ρ_{sc} are given at air mass 2, or if not the air mass is stated. The reader is referred for further statements regarding the arrangement and meaning of the table to the REVIEW for February, August, and September, 1919.

The values given for June 1 and 2 are to be substituted for the value of June 2 in the REVIEW for September, 1922, and those of July 2 and 15 are to be added to those given for July in the same number of the REVIEW.

Readers will note how very low the solar constant values are now running, compared with what they were in the earlier years of observations in South America when the average value of 1.95 prevailed. This, as readers of Volume IV of the *Annals of the Astrophysical Observatory* will recognize, is perhaps to be expected, in view of the minimum of sun spots which now prevails, for all the history of our observing indicates that high solar constant values attend maximum of sunspots and vice versa. On the other hand, as pointed out in Volume IV of the *Annals*, it not infrequently happens that individual sun spots are attended with temporary low values of the solar radiation. This was notably the case in March, 1920, and unpublished observations at Mount Harqua Hala, Ariz., indicate that it was true also for the sun-spot group which began to form about October 17, 1922. It is to be regretted that owing to sickness no observations were had in Chile during the extremely interesting period from October 12 to October 29, 1922, when this phenomenon was reported from Arizona.

I am inclined to attribute this dual association with sun spots to these considerations: (1) High solar constant values prevail at periods of maximum sun spots because the increased solar circulation brings up hotter material to the radiating surface of the sun. (2) Individual sun spots are often accompanied by protruding masses of diminished transparency, and while these protruding shafts point toward the earth they diminish the solar radiation. As the sun rotates such shafts of diminished transparency pass by, and the solar radiation recovers its normal intensity.

Date.	Solar constant.	Method.	Grade.	Transmission coefficient at 0.5 micron.	Humidity.			Remarks.
					ρ/ρ_{sc}	V. P.	Relative humidity.	
1922.								
P. M.	*cal.*					*cm.*	*Per cent.*	
June 1	1.906	$M_{2\cdot5}$	S.	0.878	[1]0.572	0.24	16	Small cumuli in east.
	1.903	$M_{2\cdot13}$						
2	1.911	$M_{2\cdot32}$	S—	.881	[2].560	.31	20	Distant cumuli over high peaks.
	1.890	$M_{2\cdot12}$						
	1.904	W. M.						
P. M.								
July 2	1.870	$M_{2\cdot44}$	S—	.888	[3].865	.12	19	Cloudless.
	1.894	$M_{2\cdot13}$						
	1.903	$M_{1\cdot89}$						
	1.893	W. M.						
A. M.								
July 15	1.927	$M_{1\cdot60}$	S.	.879	[4].636	.14	7	Small patches of cirri in southeast.
	1.931	$M_{1\cdot56}$						
	1.929	W. M.						
P. M.								
Aug. 1	1.883	$M_{2\cdot0}$	S—	.885	.680	.26	7	Cloudless.
	1.920	$M_{1\cdot63}$						
	1.908	W. M.						
5	1.915	$M_{2\cdot12}$	S—	.886	[5].742	.13	17	Do.
8	1.931	$M_{1\cdot61}$	S—	.886	[6].778	.11	5	Do.
11	1.907	$M_{2\cdot60}$	S—	.888	[7].804	.12	6	Do.
	1.899	$M_{2\cdot42}$						
	1.903	W. M.						
A. M.								
Aug. 12	1.976	E_0	VG+	.875	.747	.08	9	Cloudness.
	1.926	$M_{2\cdot5}$						
	1.934	$M_{2\cdot0}$						
	1.921	$M_{1\cdot5}$						
	1.934	W. M.						
P. M.								
Aug. 19	1.904	$M_{2\cdot10}$	S—	.889	.836	.19	10	Cloudless.
	1.909	$M_{2\cdot0}$						
	1.907	W. M.						
26	1.906	$M_{2\cdot88}$	S—	.885	[8].749	.09	17	Do.
27	1.909	$M_{2\cdot35}$	S—	.884	.737	.16	12	Do.
	1.941	$M_{2\cdot01}$						
	1.920	W. M.						
A. M.								
Aug. 28	1.937	$M_{1\cdot24}$	S—	.879	[9].795	.19	7	Cloudless.
P. M.								
Aug. 30	1.850	$M_{1\cdot74}$	S—	.887	[10].855	.09	5	Cloudless.
	1.902	$M_{1\cdot56}$						
	1.925	$M_{1\cdot32}$						
	1.917	W. M.						
Sept. 15	1.936	$M_{1\cdot57}$	U.	.885	[11].771	.17	8	Do.
16	1.925	$M_{2\cdot5}$	S—	.878	.658	.15	10	Do.
	1.920	$M_{2\cdot10}$						
	1.936	$M_{1\cdot77}$						
	1.927	W. M.						
20	1.934	$M_{2\cdot14}$	S—	.875	[12].622	.20	11	Do.
A. M.								
Sept. 27	1.936	$M_{2\cdot5}$	S.	.878	.674	.14	8	Cloudless.
	1.912	$M_{2\cdot0}$						
	1.911	$M_{2\cdot0}$						
	1.919	W. M.						
28	1.976	$M_{1\cdot20}$	S—	.874	[13].743	.69	13	Cumuli low in east.
P. M.								
Sept. 29	1.908	$M_{1\cdot91}$	S.	.881	.645	.17	9	Scattered cumuli in north and east.
	1.911	$M_{1\cdot55}$						
	1.916	$M_{1\cdot38}$						
	1.912	W. M.						
A. M.								
Oct. 1	1.923	$M_{2\cdot08}$	S.	.874	.550	.39	21	Patches of cumuli low in east.
	1.925	$M_{1\cdot89}$						
	1.924	W. M.						
P. M.								
Oct. 4	1.914	$M_{1\cdot87}$	S—	.880	[14].648	.15	13	Cloudless.
A. M.								
Oct. 5	1.913	$M_{1\cdot81}$	S.	.880	[15].669	.13	12	Cloudless.
	1.913	$M_{1\cdot58}$						
	1.912	$M_{1\cdot39}$						
	1.913	W. M.						
6	1.913	E_0	E.	.871	.642	.33	37	Do.
	1.918	$M_{2\cdot0}$						
	1.922	$M_{1\cdot5}$						
	1.918	W. M.						

[1] Air mass 2.13. [5] Air mass 2.12. [9] Air mass 1.24. [13] Air mass 1.20.
[2] Air mass 2.12. [6] Air mass 1.61. [10] Air mass 1.74. [14] Air mass 1.87.
[3] Air mass 1.89. [7] Air mass 2.42. [11] Air mass 1.57. [15] Air mass 1.81.
[4] Air mass 1.60. [8] Air mass 2.88. [12] Air mass 2.14.

36432—23——3

Date.	Solar constant.	Method.	Grade.	Transmission coefficient at 0.5 micron.	Humidity.			Remarks.
					ρ/ρ_{sc}	V. P.	Relative humidity.	
1922.								
A. M.	*cal.*					*cm.*	*Per cent.*	
Oct. 7	1.936	$M_{1\cdot44}$	S.	0.871	[16]0.648	0.20	7	Cloudless.
	1.945	$M_{1\cdot31}$						
	1.946	$M_{1\cdot21}$						
	1.943	W. M.						
8	1.933	$M_{1\cdot38}$	S.	.879	[17].704	.45	38	Do.
	1.933	$M_{1\cdot35}$						
	1.933	W. M.						
P. M.								
Oct. 10	1.921	$M_{1\cdot5}$	S.	.880	.629	.19	11	Cumuli low in east.
	1.929	$M_{2\cdot0}$						
	1.927	$M_{2\cdot0}$						
	1.926	W. M.						
11	1.902	$M_{1\cdot5}$	S—	.888	.729	.26	9	Do.
	1.912	$M_{2\cdot0}$						
	1.945	$M_{2\cdot0}$						
	1.915	W. M.						
A. M.								
Oct. 12	1.956	E_0	E.	.874	.701	.27	44	Cloudless.
	1.939	$M_{2\cdot5}$						
	1.936	$M_{2\cdot0}$						
	1.944	W. M.						
29	1.987	$M_{1\cdot59}$	S—	.878	.809	.18	11	Do.
P. M.								
Nov. 3	1.904	$M_{1\cdot58}$	S—	.862	[18].615	.29	8	Cumuli low in east.
	1.910	$M_{1\cdot51}$						
	1.936	$M_{1\cdot36}$						
	1.919	W. M.						
4	1.930	$M_{1\cdot73}$	S—	.865	[19].624	.26	6	Cloudless.
	1.940	$M_{1\cdot49}$						
	1.965	$M_{1\cdot35}$						
	1.945	W. M.						
A. M.								
Nov. 6	1.920	E_0	V. G.	.873	.585	.24	47	Cloudless.
	1.899	$M_{2\cdot0}$						
	1.893	$M_{1\cdot5}$						
	1.908	W. M.						
P. M.								
Nov. 10	1.939	$M_{2\cdot49}$	S.	.870	.606	.18	12	Cirri low in east.
	1.940	$M_{1\cdot98}$						
	1.943	$M_{1\cdot86}$						
	1.943	W. M.						
A. M.								
Nov. 14	1.957	$M_{1\cdot18}$	S—	.871	[20].740	.24	7	Cloudless.
P. M.								
Nov. 15	1.933	$M_{2\cdot04}$	S—	.859	.597	.38	16	Cumuli low in east.
	1.912	$M_{1\cdot69}$						
	1.925	$M_{1\cdot52}$						
	1.926	W. M.						
20	1.923	$M_{1\cdot28}$	S—	.874	[21].750	.49	20	Do.
25	1.914	$M_{2\cdot5}$	S.	.868	.562	.28	6	Cirri in east and south
	1.916	$M_{2\cdot0}$						
	1.915	W. M.						
30	1.921	$M_{1\cdot61}$	S—	.880	[22].799	.11	13	Cirri low in east.
	1.925	$M_{1\cdot46}$						
	1.923	W. M.						
Dec. 2	1.917	$M_{1\cdot84}$	S—	.877	[23].780	.11	14	Cloudless.
	1.904	$M_{1\cdot67}$						
	1.911	W. M.						
11	1.906	$M_{2\cdot84}$	S—	.889	[24].471	.29	5	Cumuli in east.
12	1.908	$M_{1\cdot77}$	S—	.855	[25].544	.77	25	Cumuli in east. Cirri forming near sun prevented further observations.
14	1.927	$M_{2\cdot13}$	S.	.870	.535	.37	48	Cumuli low in east.
	1.925	M_{2}						
	1.926	W. M.						
15	1.860	E_0	V. G.	.880	.498	.42	4	Cumuli low in north and east.
	1.936	$M_{1\cdot51}$						
	1.904	$M_{2\cdot0}$						
	1.893	W. M.						
A. M.								
Dec. 25	1.911	$M_{1\cdot45}$	U.	.859	[26].489	.48	.33	Cirri in north and east

[16] Air mass 1.44. [19] Air mass 1.73. [22] Air mass 1.61. [25] Air mass 1.77.
[17] Air mass 1.36. [20] Air mass 1.18. [23] Air mass 1.84. [26] Air mass 1.45.
[18] Air mass 1 58. [21] Air mass 1.28. [24] Air mass 2.34.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was somewhat lower than usual at land stations in Newfoundland and on the American coast, north of Hatteras. It was slightly above the normal in the West Indies and Gulf of Mexico, while in the Azores and on the coast of Great Britain the positive departures were quite large.

Fog was unusually prevalent on the Grand Banks and off the New England coast, and was also observed on three days in the Gulf of Mexico, while the eastern section of the steamer lanes was comparatively free.

Taking the ocean as a whole, the number of days on which winds of gale force were observed, was not as great as in December, although considerably above the normal for January. In the southwestern section of the ocean there was comparatively little difference between the two months, although in the eastern part of the steamer lanes the number for the month under discussion was slightly less than usual.

A large number of casualties was reported, and during the last two decades of the month, unusual unfavorable conditions prevailed over the region between the Azores and Bermudas.

On the 1st there was a fairly well developed disturbance in mid-ocean that moved rapidly eastward, as on the 3d it was in the vicinity of the North Sea, and a number of vessels in the eastern section of the steamer lanes reported strong gales, as shown by following storm logs:

British S. S. *Manchester Spinner:*

Gale began on December 31, wind SW., 6. Lowest barometer 29.43 inches at 3:30 p. m. on the 2d, wind W., in latitude 50° 32′ N., longitude 22° 07′ W. End on the 2d, wind WNW. Highest force of wind 12; shifts 2 points.

British S. S. *Manchester Merchant:*

Gale began on the 1st, wind SW. Lowest barometer 29.05 inches at noon on the 1st, wind SW., 9, in latitude 51° 33′ N., longitude 33° 41′ W. End on the 2d, wind NW. Highest force of wind 12; shifts WSW.–NW.

On the 1st Cape Hatteras was the center of a second area of low pressure, that moved rapidly northeastward and on the following day was over the western part of Newfoundland. Storm logs:

French S. S. *Rochambeau:*

Gale began on the 1st, wind S. Lowest barometer 29.61 inches on the 1st, wind SSW., 11, in latitude 41° N., longitude 64° 35′ W. End on the 1st, wind WNW. Highest force of wind 11, SSW.; shifts SSW.–WNW.

American S. S. *Lake Gilboa:*

Gale began on December 31, wind SSE. Lowest barometer 29.70 inches on the 1st, wind S., 10, in latitude 35° 12′ N., longitude 75° 18′ W. End on the 1st. Highest force of wind 10, S.; shifts SSE.–S.

Dutch S. S. *Leersum:*

Gale began on the 1st, wind SSW. Lowest barometer 29.76 inches at 2:30 a. m. on the 2d, wind N., 10, in latitude 40° 33′ N., longitude 61° 45′ W. End on the 2d. Highest force of wind 11; shifts SSW.–W–. WNW.

On the 5th moderate gales were reported by vessels off the European coast and on the 6th a disturbance of limited extent was central near latitude 45° N., longitude 35° W. Its easterly movement was fairly rapid, as on the 8th the center was about 5° west of the Irish coast. From the 8th to the 10th the rate of translation lessened, as on the latter date it was central over the north of Scotland, and strong westerly to northwesterly gales accompanied by rain, hail, and snow were prevalent over the region between the 30th meridian and European coast. Storm logs follow:

American S. S. *Wildwood:*

Gale began on the 5th, wind S. Lowest barometer 29.71 inches at 4 p. m. on the 6th, wind SW., 7, in latitude 44° 45′ N., longitude 37° W. End on the 7th, wind NW. Highest force of wind 10; shifts SSW.–NE. and backing to NW.

British S. S. *Kenbane Head:*

Gale began on the 7th, wind WSW. Lowest barometer 29.19 inches at 10 p. m. on the 8th, wind WSW., 10, in latitude 54° 46′ N., longitude 16° 40′ W. End on the 10th, wind NW. Highest force of wind 10, W., shifts WSW.–NW.

American S. S. *Monmouth:*

Gale began on the 9th, wind NW. Lowest barometer 30.01 inches at 2 a. m. on the 9th, wind NW., 9, in latitude 50° 20′ N., longitude 13° 15′ W. End on the 10th, wind NW. Highest force of wind 10; steady NW.

British S. S. *Ballygally Head:*

Gale began on the 8th, wind S. Lowest barometer 28.15 inches at 5 p. m. on the 9th, wind WNW., 9, in latitude 58° 30′ N., longitude 16° 40′ W. End on the 10th, wind NW. Highest force of wind 11, SSW.; shifts S.–N. by W. 17 points, then NW.

On the 9th Halifax, N. S., was near the center of a moderate disturbance that increased in intensity as it traveled slowly in an east-northeasterly direction, and on the 10th and 11th southerly to westerly gales were reported from the region between the 30th and 40th parallels and 55th and 70th meridians. Storm logs follow:

British S. S. *Comanchee:*

Gale began on the 8th, wind W. Lowest barometer 29.37 inches at 4 a. m. on the 10th, wind W., 7, in latitude 37° 23′ N., longitude 67° 16′ W. End on the 11th, wind N. Highest force of wind 10; shifts W.–NW.

American S. S. *City of Freeport:*

Gale began on the 10th, wind SSW. Lowest barometer 29.58 inches at 8 a. m. on the 11th, wind S., 8, in latitude 37° 11′ N., longitude 58° 20′ W. End on the 11th, wind WNW. Highest force of wind 9; shifts S.–WNW.

On the 12th New York was surrounded by an area of moderate low pressure that afterwards developed into one of the worst storms of the month; increasing in intensity, and moving but slightly, the storm area on the 13th and 14th extended as far south as the 30th parallel. Charts VIII to X show the conditions from the 13th to 15th, inclusive. Storm logs follow:

American schooner *Frank A. Morey:*

Gale began on the 11th, wind SSW. Lowest barometer 29.89 inches at 4 a. m. on the 12th, wind SW., in latitude 35° N., longitude 75° 25′ W. End on the 12th, wind WSW. Highest force of wind 9; shifts SSW.–WSW.

British S. S. *San Bruno:*

Gale began on the 12th, wind SW. Lowest barometer 29.93 inches at noon on the 12th, wind SW., in latitude 33° N., longitude 71° 42′ W. End on the 14th, wind N. Highest force of wind 10; shifts SW.–WNW.

American S. S. *Effna:*

Gale began on the 13th, wind SW. Lowest barometer 29.62 inches on the 13th, wind W., in latitude 33° 54′ N., longitude 60° 53′ W. End on the 14th, wind NW. Highest force of wind 9; steady W.

British S. S. *Henry Deutsch de la Meurthe:*

Gale began on the 12th, wind S. Lowest barometer 29.39 inches at 10 p. m. on the 12th, wind S., 8, in latitude 39° 20′ N., longitude 57° 35′ W. End on the 13th, wind NW. Highest force of wind 10; shifts S.–SW.–NW.

German S. S. *Bayern:*

Gale began on the 13th, wind SSE. Lowest barometer 29.18 inches at 5 a. m. on the 14th, wind WSW., 12, in latitude 42° 4′ N., longitude 45° 50′ W. End on the 16th, wind NNE. Highest force of wind 12, WSW.; shifts SSE.–WSW.–WNW.

Italian S. S. *Giuseppi Verdi:*

Gale began on the 14th, wind S. Lowest barometer 29.34 inches at noon on the 14th, wind S., 8, in latitude 37° N., longitude 44° 22′ W. End on the 18th, wind NNE. Highest force of wind 10; shifts not given.

American S. S. *W. H. Tilford:*

Gale began on the 13th, wind SSW. Lowest barometer 29.59 inches at 10 p. m. on the 13th, wind WNW., in latitude 37° N., longitude 55° 48′ W. End on the 16th, wind NW. Highest force of wind 10, WSW.; shifts SSW.–S.–WNW.

On the 15th there was a second disturbance central off Nantucket and from that date until the 17th heavy weather prevailed over the region between the 55th meridian and the American coast, the storm area extending as far south as the Bermudas. It was in this storm that the Italian S. S. *Montello* was lost, her ship's company being rescued by the crew of the Italian S. S. *Giuseppi Verdi* on the 16th, near latitude 37° N., longitude 57° W. Storm logs follow:

American S. S. *Harvester:*

Gale began on the 14th, wind NE. Lowest barometer 29.98 inches at 7 p. m. on the 15th, wind NW., in latitude 33° 34′ N., longitude 77° 49′ W. End on the 18th, wind S. Highest force of wind 9; shifts NE.–E.–S.–SW.–W.–NW.

American S. S. *Satartia:*

Gale began on the 17th, wind W. Lowest barometer 29.69 inches on the 17th, wind WNW., 8, in latitude 36° 23′ N., longitude 64° 10′ W. End on the 18th, wind NNW. Highest force of wind 10; shifts W.–W.–WNW.–NW.–NNW.

On the 17th and 18th northeasterly winds of gale force were encountered in the West Indies as shown by following storm log:

American S. S. *Lake Fairport:*

Gale began on the 17th, wind NE. Lowest barometer 30 inches at 4 p. m. on the 18th, wind NE., in latitude 18° 17′ N., longitude 75° 39′ W. End on the 18th, wind ENE. Highest force of wind 9; shifts NE.–ENE.

On the 19th and 20th favorable weather was the rule over the entire ocean except that moderate gales were reported from a limited area off the coast of Scotland.

On the 20th and 21st northerly winds of gale force, accompanied by unusually high barometic readings, were reported by vessels near latitude 40° N., longitude 45° W. Storm log follows:

British S. S. *Epsom:*

Gale began on the 20th, wind NNE. Lowest barometer 30.43 inches at 8 a. m. on the 21st, wind NNE., 8, in latitude 40° 18′ N., longitude 48° W. End on the 22d, wind ENE. Highest force of wind 9; shifts NNE. to NE.

Charts XI to XIII show the conditions from the 24th to 26th, inclusive, when the greater part of the ocean was swept by gales of varying intensities. On the 25th and 26th there were two areas of low pressure; the first central off the New England coast and the second near latitude 45° N., longitude 40° W. On the 26th the western disturbance was especially violent over a limited area in the vicinity of Nantucket Shoals. Storm logs follow:

British M. S. *Dominion Miller:*

Gale began on the 23d, wind SW. Lowest barometer 29.75 inches at noon on the 23d, wind SW., 7, in latitude 43° 36′ N., longitude 53° W. End on the 24th, wind N. Highest force of wind 10, N.; shifts SW.–W.–NW.–N.

British M. S. *Dominion Miller:*

Gale began on the 25th, wind N. Lowest barometer 29.25 inches at noon on the 25th, wind N., 8, in latitude 41° 14′ N., longitude 64° 26′ W. End on the 26th, wind N. Highest force of wind 12; shifts SE.–S.–SW.–W.

British S. S. *Verentia:*

Gale began on the 23d, wind SE. Lowest barometer 29.40 inches at 8 p. m. on the 25th, wind NW., 9, in latitude 41° 55′ N., longitude 45° 54′ W. End on the 26th, wind W. Highest force of wind 10, NW.; steady NW.

American S. S. *Texan:*

Gale began on the 24th, wind SE. Lowest barometer 29.31 inches at 6 p. m. on the 25th, wind 11, S., in latitude 44° 39′ N., longitude 37° W. End on the 26th, wind SE. Highest force of wind 11; shifts SE.–ESE.–S.

Dutch S. S. *Bergerdijk:*

Gale began on the 25th, wind SSE. Lowest barometer 29.16 inches at 1 p. m. on the 25th, wind SSE., 8, in latitude 42° 09′ N., longitude 64° 05′ W. End on the 26th, wind NW. Highest force of wind 9; shifts SSE.–W.

Dutch S. S. *Amersfoort:*

Gale began on the 20th, wind ENE. Lowest barometer 29.59 inches at 5:30 a. m. on the 24th, wind SW., 2, in latitude 35° 22′ N., longitude 43° 23′ W. End on the 25th, wind NNW. Highest force of wind 9; shifts SSW.–NW.

French S. S. *Roma:*

Gale bagan on the 24th, wind SE. Lowest barometer 29.56 inches at 10 a. m. on the 25th, wind SE., 10, in latitude 38° 09′ N., longitude 30° 45′ W. End on the 26th, wind SW. Highest force of wind 10, SE.; steady SE.

Belgian S. S. *Sunoco:*

Gale began on the 25th, wind SE. Lowest barometer 29.46 inches at 7 a. m. on the 25th, wind SE., 9, in latitude 45° 14′ N., longitude 36° 10′ W. End on the 27th, wind SSE. Highest force of wind 10; shifts SSE.–ESE.

The weather conditions over the ocean, as a whole, were unfavorable during the remainder of the month, although the intensity of the gales and extent of the storm areas varied considerably from day to day. The most unusual feature was the persistent intrusion of heavy winds in the region between the Azores and Bermudas, extending below the 30th parallel. On the 30th the greater part of the ocean west of the 30th meridian was storm swept, while on the 31st moderate weather prevailed over quite an extensive area in mid-ocean. Storm logs follow:

British S. S. *Idaho:*

Gale began on the 24th, wind NW. Lowest barometer 29.01 inches at 4 a. m. on the 27th, wind WNW., in latitude 41° 12′ N., longitude 52° 48′ W. End on the 28th, wind N. Highest force of wind 9; shifts WNW.–NW.

British S. S. *Verbania:*

Gale began on the 26th, wind WNW. Lowest barometer 29.19 inches at noon on the 27th, wind WNW., in latitude 41° 08′ N., longitude 56° 58′ W. End on the 28th, wind NW. Highest force of wind 9, NNW.; steady WNW.

American S. S. *Quistconck:*

Gale began on the 29th, wind SW. Lowest barometer 29.70 inches at 10 a. m. on the 29th, wind SW., 7, in latitude 31° 56′ N., longitude 49° 12′ W. End on the 31st, wind NW. Highest force of wind 9, SW.; shifts SW.–WNW.

American S. S. *Schodack:*

Gale began on the 29th, wind S. Lowest barometer 28.95 inches at 2 p. m. on the 30th, wind S., 12, in latitude 44° 20′ N., longitude 35° 20′ W. End on the 31st, wind W. Highest force of wind 12; shifts S.–W.–SW.

British S. S. *Saint Andrew:*

Gale began on the 29th, wind SE. Lowest barometer 28.50 inches at 7 p. m. on the 30th, wind SW., 6, in latitude 49° N., longitude 38° 06′ W. End on the 31st, wind WNW. Highest force of wind 10; shifts S.–W.–NW.

British S. S. *Idaho:*

Gale began on the 29th, wind NW. Lowest barometer 29.89 inches on the 29th, wind NW., in latitude 40° 37′ N., longitude 65° 55′ W. End on the 30th, wind NW. Highest force of wind 10; steady NW.

American S. S. *Glen Ridge:*

Gale began on the 31st, wind NNW. Lowest barometer 29.84 inches at noon on the 31st, wind NNW., 8, in latitude 42° 06′ N., longitude 54° 31′ W. End on February 1, wind NW. Highest force of wind 10; shifts NNW.–NW.

French S. S. *Rochambeau:*

Gale began on the 30th, wind SSE. Lowest barometer 29.37 inches at midnight on the 30th, wind S., 11, in latitude 49° 05′ N., longitude 26° W. End on the 31st, wind WSW. Highest force of wind 12; shifts not given.

American S. S. *Wildwood:*

Gale began on the 29th, wind S. Lowest barometer 29.92 inches at 8 p. m. on the 31st, wind SW., 10, in latitude 39° 15′ N., longitude 31° 02′ W. End on February 1, wind WNW. Highest force of wind 11; shifts SW.–WNW.

NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

Generally speaking, the weather over the North Pacific Ocean during January was more disturbed than during the previous month. Extreme storm conditions, however, were not so prevalent, and only one report of a wind velocity attaining hurricane force has been received. That velocity occurred on the 3d of the month, near the 44th parallel, 162d meridian of east longitude. Over the northern steamship routes much snow fell, frequently observed as heavy. Near midnight of the 10th, when near latitude 43° N., longitude 158° E., the American S. S. *West Kader* encountered very heavy snow while in the calm center of a storm. At its heaviest, 4 inches fell in the course of 20 minutes.

At Honolulu conditions were quite different from those of December. The weather was generally cloudy, and rain, frequently heavy, fell on all but two days. In contrast to the abnormally low wind velocity of the previous month, January had the highest average wind velocity, 11.7 miles per hour, in the records of the station. A storm which swept the Hawaiian Islands from the morning of the 13th until the night of the 16th caused considerable damage. The highest velocity at Honolulu was at the rate of 56 miles per hour, which was 8 miles higher than the previous record. On the morning of the 14th two light earthquake shocks were experienced during the height of the storm.

High presssure covered the China coast during the greater part of the month, thereby causing a strong prevalence of the northeast monsoon. Two storms, however, are known to have issued from this area, entering the sea, one on the 7th, the other on the 14th. From the 1st to the 3d the steep gradients between the Manchurian HIGH, with a crest of 30.87 inches, and the moderately deep depression of a cyclone central east of Sakhalin, caused strong gales over Japan and the vicinity.

On the 2d there were apparently three centers of cyclonic activity along or near the 50th parallel, stretching from coast to coast. The low pressure trough was persistent for several days. During this period a number of vessels, eastward bound, encountered rough weather along the northern routes, more particularly west of the 180th meridian. The heaviest gales occurred on the 3d and 4th, and velocities of force 8 to 10 were widespread. The Canadian Pacific S. S. *Empress of Australia* reported a southwest hurricane at noon of the 3d, as previously noted. Pressures over a wide area were unusually low. Second Officer Parker, of the British S. S. *Talthybius*, Yokohama toward Victoria, said in this respect:

> A very marked feature of our passage has been the exceptionally low reading of the barometer, from about longitude 162° E. up to about 140° W., where a steady rise started. With the exception of one gale, the weather we experienced was comparatively fine from the 180th meridian, and not what we might have expected from so low a barometer. Our lowest reading (corrected) was 28.39 inches, in latitude 46° 16′ N., longitude 165° 56′ E., on the 3d.

Early on the morning of the 3d the Canadian S. S. *Canadian Winner*, while in nearly the same position, reported a corrected pressure reading of 28.26 inches, the lowest noted on the Pacific for the month.

The Asiatic cyclone of the 7th was causing gales over Japan on the 8th. On the 9th and 10th the storm moved northeastward, and while it gave fresh gales to shipping southward of the Aleutians during those dates, it finally disappeared by entering the strong LOW central on the 11th over the lower reaches of Bering Sea.

The storm that left China on the 14th was attended by gales over Japan and adjacent waters on the 15th. Two Japanese steamships, eastward bound from Yokohama, were in this storm on that date, but reported no higher winds than force 9. One, the *Tokiwa Maru*, was in latitude 37° 57′ N., longitude 145° E., with pressure of 29.10 inches, wind from the south. The other, the *Korea Maru*, in latitude 34° 41′ N., longitude 140° 38′ E., had a southwest gale, with pressure of 29.40 inches. The storm seems to have moved northeastward, like its predecessor, and merged with the Aleutian LOW.

In addition to the continental storms and the perturbations of the Aleutian LOW, two or three oceanic depressions, or storms, moved into the field of observation from lower latitudes. The first was that of the 13th, which swept the Hawaiian Islands with an intensity unusual for that area. The pressures were not especially low, the minimum at Honolulu being 29.68 inches on the 14th, and no other pressures as low being observed at this time by vessels to the southward of the 40th parallel in this vicinity. The highest wind force observed was 10 from the north, noted by the American S. S. *City of Los Angeles*, on the 14th, in latitude 22° 40′ N., longitude 155° W. This storm, by the afternoon of the 15th, had moved northward and lost its identity in the LOW then covering the Gulf of Alaska.

On the 20th the pressure at Honolulu had again become moderately low, though no storm conditions of moment developed. About the 22d a depression appeared off the upper California coast, and another was found to the westward of Hawaii. On the 25th pressure was low at Midway Island. The relationship between these depressions and that over Hawaii on the 20th, while possible, is in neither case assured.

The Mexican and Central American coast region was generally quiet throughout the month, with few gales reported. The winds were mostly from westerly to northerly directions. Strong northers occurred over the Gulf of Tehuantepec, particularly on the 18th, 19th, and 20th.

An examination of the more permanent pressure elements shows the eastern North Pacific HIGH to have been quite firmly intrenched from the 1st until about the 14th. Following the Hawaiian storm of the 14th, pressure became high over and to the westward of the islands on the 16th. This anticyclonic condition gradually spread eastward, as storm conditions receded, till by the 18th it was once more established along the California-Hawaiian routes. A storm, built up in this area on the 21st and 22d, passed into the California coast on the 23d, and from then until the close of the month the HIGH dominated the weather conditions over most of the eastern Pacific except the Gulf of Alaska.

The Aleutian LOW exhibited its usual fluctuation in movement and intensity. It was quite strong over the Gulf of Alaska during the greater portion of the month, and over the western Aleutians during much of the early half. Offshoot storms from the gulf LOW entered the Canadian mainland on the 2d, 7th, 11th, 16th, and 27th. A mid-Pacific high pressure area bulged into the Aleutian LOW region in the neighborhood of Dutch Harbor during much of the month from the 13th to the 26th.

Pressure conditions over the eastern portion of the ocean, as shown by observations at the island stations, were, in general, the reverse of those in the preceding month. At Dutch Harbor, where in December there was a deficiency of 0.15 inch, pressure rose to normal, or approximately 29.71 inches, based on p. m. observations. The net rise was 0.31 inch. The highest pressure recorded was 30.46 inches, on the 20th; the lowest, 29.88 inches,

on the 11th. Absolute range, 1.58 inches, as compared with 1.46 inches in December. At Midway Island the average pressure was 30.11 inches, or 0.11 inch above the normal, being a net rise of 0.23 inch. The highest was 30.38 inches, on the 9th; the lowest, 29.82, on the 25th. At Honolulu the average pressure was 29.98 inches, or some 0.04 inch below normal. This was 0.10 inch below the average for December. The highest pressure, 30.16 inches, occurred on the 16th; the lowest, 29.68, on the 14th.

Fog seems to have been less prevalent in January than in December. The only report of its occurrence in east longitude was on the 17th, in latitude 28° N., longitude 163°. In west longitude fog was observed on the 18th in latitude 41° N., longitude 172°, and by one vessel sailing along latitude 38° N. between longitudes 162° and 148° W., during the 26th to 29th. Fog occurred along the American coast, more particularly south of the 34th parallel, on several days, as indicated by ships' reports. It was observed in the neighborhood of San Pedro on the 17th, 18th, 21st, and 22d, and as far south as latitude 24° N., longitude 112° W., on the 7th and 8th.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

Nova Scotia.—ST. JOHNS, N. B., January 26.—Huge snow drifts blown in the gale that followed last night's severe snow and sleet storm, blocked rail traffic in this section to-day and several train trips were canceled.—*New York Post, January 27, 1923.*

HALIFAX, January 26.—The British freighter *Cairnmona*, which left Leith for Portland, Me., January 16, has been caught in a great ice field off Cape Race, according to a radio message from the steamer to the marine and fisheries department. The message sent yesterday afternoon and signed by Captain Berlin, said the ice field extended north and south as far as the eye could reach and appeared to be about 18 miles across east and west. *New York Post, January 27, 1923.*

France—CANNES, January 5.—Unprecedented cold weather gripped the Riviera to-day, which caused hundreds of society folk wintering here to send home for heavy clothes.—*Washington Times-Herald, January 6, 1923.*

PARIS, January 9.—The Seine, which twice this winter has threatened to repeat the disastrous flood of 1910, is rising again and some alarm is felt unless the rains cease.—*Binghamton Morning Sun, January 10, 1923.*

PARIS, January 18.—The first snow of the season fell in Paris to-day. It was a light fall, coming after the two-day cold wave that now prevails over France, with temperatures ranging around freezing.—*Chicago Evening Post, January 18, 1923.*

Jamaica.—KINGSTON, January 26.—The northern and Central parishes have been visited by strong winds and heavy rains, which have caused considerable damage to the banana plantations and have seriously imperiled the next crop.—*Chicago Daily News, January 26, 1923.*

Hawaii.—HONOLULU, January 15.—A howling 55-mile gale, the stiffest ever recorded in the islands, accompanied by two earthquake shocks, swept and rocked Hawaii yesterday, last night and early this morning, causing at least one death.—*Washington Post, January, 16, 1923.*

Agentina.—BUENOS AIRES, January 24.—Buenos Aires to-day sweltered under a temperature of 104° F., which was accompanied by an extraordinarily hot wind, not unlike a simoon. There were numerous prostrations. The temperature was the highest recorded here in 15 years.—*New York Herald, January 25, 1923.*

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

By ALFRED J. HENRY.

The outstanding feature of the month was the high temperature for the season that prevailed in all parts of the country except New England and along the middle Pacific coast. An unusually large number of cyclonic storms passed across the country, some of which developed greatly in intensity off the Canadian Maritime Provinces. As a consequence the weather was cold and stormy in New England with considerable snow in strong contrast to the weather elsewhere in the United States.

Precipitation was slightly below the normal for the country as a whole, although no marked deficits occurred in any part of the country.

CYCLONES AND ANTICYCLONES.

By W. P. DAY.

Cyclonic activity was above the average during the month of January, if one considers merely the number of high and low pressure areas which crossed the field of observation. However, severe winter weather was confined mostly to the northern portion of the Atlantic States. The stormy weather in New England and New York was caused by a frequent development of important secondary storms off the New Jersey coast, bringing high northeasterly winds, often with heavy snow, and followed by sweeping cold waves. Anticyclones caused by outflowing polar air (Alberta and Hudson Bay HIGHS) generally remained north of latitude 40° N., while the built up HIGHS from the Pacific moved in a group much farther south. Tables showing the number of cyclones (LOWS) and anticyclones (HIGHS) by types follow:

Cyclones.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total
January, 1923....	8.0	2.0	2.0	1.0	2.0	1.0	.....	3.0	2.0	21.0
Average number, 1892-1912, inclusive.....	4.7	2.5	0.9	0.4	1.4	1.5	0.4	0.4	0.5	12.7

Antiyclones.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
January, 1923.....	1.0	6.0	6.0	3.0	3.0	19.0
Average number, 1892-1912, inclusive	0.8	0.6	5.5	1.7	0.4	9.0

FREE-AIR SUMMARY.

By L. T. SAMUELS, Meteorologist.

The outstanding feature of the month was the prevalence of positive temperature departures, particularly in the middle and lower latitudes of the country. (See Table 1.) The departures found at the aerological stations conformed in amount closely with those shown in climatological Chart III. At every station except Ellendale and Groesbeck the departures fell off appreciably in amount with increase in altitude, becoming in some cases negative in the highest levels. At Ellendale they increased slightly in amount with increasing altitude. At this station, however, the departures in the lower levels were exceedingly small. At Groesbeck, the southernmost station, large positive departures persisted to 5,000 m.

Maximum temperature records were broken during the month for various levels at Broken Arrow, Ellendale, and Groesbeck. On these days there was usually found a large temperature inversion, its influence extending to heights between 2,000 m. and 3,000 m. where the temperature was higher even than that at the surface.

Mean relative humidities for the month were mostly below normal, exceptions being found in the lower levels at Ellendale, the upper levels at Groesbeck, and all levels at Royal Center. Notwithstanding the wide fluctuations found in this element on individual days, the monthly means differ comparatively little from the normal values as shown in the table.

Mean vapor pressures varied only slightly from the monthly normals, the departures being in general positive at those stations having the greatest positive temperature departures and negative elsewhere. At Groesbeck, where positive temperature departures persisted at all levels, the vapor pressure departures were greatest and all positive.

Atmospheric electric potentials, markedly higher than normal, were observed on 8 of the first 10 days of the month at Groesbeck, Tex.

In Table 2 are shown the resultant wind velocities and directions for the month and their normal values, the latter being based on the period indicated for each station in the heading of the table. These resultants show rather unique characteristics for the various stations. In the lower levels at Broken Arrow where the south component is strongly marked the resultant velocity exceeds its normal appreciably, thus conforming with the large positive temperature departures found at this station in these levels. At Drexel the normal amount of the north component was only slightly less pronounced in the lower levels in the resultant for the month. In the higher levels, however, there is a considerable shift to the southward. This latter fact is likewise true at the other two northern stations and is mentioned in connection with the statement by E. H. Bowie appearing in this REVIEW under the section of "Weather and storm warnings," to the effect that the paths of the anticyclones were generally in relatively high latitudes and the cold waves of the month for this reason were confined to the more northern sections of the United States. Due West shows very little difference between the resultant for the month and the averages. The period of record here, however, is too short to permit strict comparison. In comparing the monthly means and normals at Ellendale there is found in the lower levels a greater north component for the month, while in the upper levels a smaller one occurred. This fact is in harmony with the temperature departures shown in Table 1. At Groesbeck the south component very decidedly exceeded the normal direction as well as the resultant velocity for the month. This was most pronounced in the lower levels, conforming remarkably with the consistent positive temperature departures at this station. Practically no difference is found between the resultant and normal winds at Royal Center where temperature departures were comparatively small.

Upper winds of hurricane velocity prevailed frequently over some sections of the country. At Drexel for the two-week period (7th–20th) these strong winds continually beat down the kites and prevented the reaching of high altitudes. Similar winds were general above Due West during the week ending the 13th and above Royal Center at frequent intervals throughout the month, causing the kites to beat down.

Following is a list of the stations reporting velocities of 40 m. p. s. or higher occurring during the month:

Station.	Date.	Velocity.	Direction.	Altitude.
		m. p. s.		*m.*
Broken Arrow, Okla.	10	40	NW.	10,200
Do.	12	51	W.	7,500
Do.	16	42	NW.	7,900
Drexel, Nebr.	15	50	NW.	4,000
Due West, S. C.	5	40	W.	7,300
Do.	10	46	WNW.	4,000
Do.	16	80	WNW.	6,400
Ellendale, N. Dak.	21	42	NNW.	4,500
Groesbeck, Tex.	2	46	WNW.	2,800
Mitchel Field, N. Y.	18	42	SW.	2,700

The extraordinary velocity of 80 m. p. s. reported from Due West on the morning of the 16th demands careful consideration before being accepted as correct. That high velocities were general over this region at this time is shown by the following reports from surrounding stations:

Station.	Velocity.	Direction.	Altitude.
	M.p.s.		*M.*
Fort Bragg, N. C.	35	WNW.	4,500
Fort Benning, Ga.	34	NW.	3,000
Camp Custis, Va.	32	NW.	4,000

Furthermore, the afternoon observation at Due West showed a velocity of 43 m. p. s. from NW. at 2,500 m. A two-theodolite run started immediately after the first observation proved unsuccessful, however, when the balloon was lost to view from one of the observing stations. The weather map on this date shows this region to have been under the influence of a high pressure area central over Texas, with a deep area of low barometer off the Gulf of St. Lawrence. The 2,000 m. pressure map as drawn from surface observations by the method de-

scribed in MONTHLY WEATHER REVIEW SUPPLEMENT No. 21 indicates the persistence of this pressure distribution to this height, and pilot balloon observations at numerous stations on this date clearly showed the same gradient with high velocities to 4,000 m., the maximum of the observations.

The following note by the observer at Royal Center describes an interesting phenomenon observed at that station on the 15th:

During the second flight of a series on January 15 a peculiar cloud formation was observed about 1:15 p. m. The predominating clouds at that time were 5 ASt from the West with here and there a detached portion of StCu from the Northwest. As a group of three of the broken StCu floated past the reel shelter it was noted that each had a fringe cloud hanging from underneath similar in appearance and structure to the down streamers of a summer rain cloud. The streamers, however, were not as dark colored as those of a rain cloud. No precipitation had occurred at any time during the day and none occurred during the remainder of the day. The upper parts of the clouds were broken into small portions resembling ACu which were apparently carried along with the main body of the cloud and retained their relative positions to them. Interwoven among the small clouds were wisps of other clouds having the appearance of smoke streamers or false cirrus. These also floated along with the StCu cloud. The wind velocity at an altitude of 1,000 meters, probably about the height of the StCu cloud was 20 m. p. s., as shown by the pilot balloon observation at 2 p. m. These clouds retained their peculiar formation until they passed out of sight in an easterly direction.

It is presumed that the phenomenon described was falling snow, evaporating before reaching the earth. The kite record made during this time shows a sharp decrease in the relative humidity (from 90 to 37 per cent) of the air immediately below this cloud layer. This dryness would aid evaporation. The fact that snow flurries occurred the next morning seems of further significance.

Easterly winds above 4,000 m., which at this season of the year are rare, were reported as follows:

Station.	Altitude.	Direction.	Velocity.	Date.
	M.		*M.p.s.*	
Camp Lewis, Wash.	8,400	e.	5	20
Do.	6,200	nne.	16	24
Do.	6,400	nne.	12	29
Crissy Field, Calif.	4,000	ne.	13	31
Fort Riley, Kans.	4,000	ese.	4	22
Groesbeck, Tex.	4,000	nne.	5	16
Key West, Fla.	4,400	nne.	4	22
Do.	5,300	nne.	4	26
Do.	9,000	e.	3	29
Do.	9,000	ne.	24	31
Royal Center, Ind.	4,700	sse.	11	23
San Francisco, Calif.	4,200	nne.	26	31

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during January, 1923.*

TEMPERATURE (°C.).

Altitude, m. s. l. (*m.*)	Broken Arrow, Okla. (233*m.*)		Drexel, Nebr (396*m.*)		Due West, S. C. (217*m.*)		Ellendale, N. Dak. (444*m.*)		Groesbeck, Tex. (141*m.*)		Royal Center, Ind. (225*m.*)	
	Mean	Departure from 5-year mean.	Mean	Departure from 8-year mean.	Mean	Departure from 2-year mean.	Mean	Departure from 6-year mean.	Mean	Departure from 5-year mean.	Mean	Departure from 5-year mean.
Surface	9.4	+4.4	−1.8	+3.8	9.1	+1.5	−10.0	+0.4	13.1	+4.0	−1.7	+1.6
250	9.3	+4.3	.....	.....	9.0	+1.5	.....	.....	13.0	+4.3	−1.9	+1.5
500	8.7	+4.3	−1.7	+4.0	8.7	+2.1	−9.9	+0.4	12.8	+4.7	−3.4	+1.0
750	8.2	+4.1	−1.0	+4.4	7.9	+1.9	−9.4	+0.4	12.2	+4.3	−4.1	+0.7
1,000	7.7	+3.7	−0.4	+4.1	6.9	+1.7	−7.8	+0.6	11.4	+3.3	−3.8	+1.0
1,250	7.0	+3.2	−0.1	+3.8	5.7	+1.4	−7.0	+0.5	10.8	+3.0	−3.8	+1.1
1,500	6.2	+2.8	−0.7	+3.3	4.5	+1.1	−6.9	+0.6	10.4	+3.1	−4.4	+0.8
2,000	4.3	+2.2	−3.0	+2.3	2.2	+0.8	−7.5	+1.6	8.9	+3.2	−5.9	+0.1
2,500	1.6	+1.7	−6.1	+1.4	−0.1	+0.6	−9.6	+1.7	6.5	+3.0	−7.9	−0.3
3,000	−0.9	+1.7	−8.8	+1.1	−2.4	+0.4	−12.5	+1.5	4.0	+2.9	−10.3	−0.5
3,500	−4.2	+1.0	−11.3	+1.0	−5.1	0.0	−15.6	+1.3	1.4	+2.9	−13.6	−1.3
4,000	−8.0	+0.2	−14.7	+0.3	−9.7	−1.2	−18.2	+1.2	−1.4	+2.8	.....	.....
4,500	−11.6	0.0	−17.4	+0.6	−13.2	−1.5	−20.5	+1.3	−4.3	+2.8	.....	.....
5,000	.....	.....	.....	.....	−16.5	−1.9	.....	.....	−7.6	+3.0	.....	.....

RELATIVE HUMIDITY (PER CENT).

Surface	59	−11	76	−5	63	−3	89	+7	70	−7	81	+2
250	59	−11	.....	.....	62	−4	.....	.....	69	−7	81	+2
500	55	−9	73	−5	55	−7	87	+7	67	−7	78	+4
750	52	−7	66	−6	52	−7	78	+5	64	−6	73	+3
1,000	49	−5	59	−7	49	−7	67	+2	61	−3	66	+2
1,250	45	−5	55	−7	48	−9	60	+1	59	−1	62	+3
1,500	41	−5	55	−4	46	−11	56	−1	57	0	60	+5
2,000	35	−6	54	−3	42	−10	53	−3	54	+2	56	+7
2,500	33	−6	56	0	37	−13	54	−2	52	+2	64	+14
3,000	32	−5	54	−2	35	−13	55	−1	50	+3	61	+10
3,500	30	−7	51	−3	38	−11	46	−7	48	+3	72	+16
4,000	30	−4	50	−3	40	−9	40	−11	46	+5	.....	.....
4,500	30	−4	46	−7	40	−9	57	00	44	+5	.....	.....
5,000	.....	.....	.....	.....	40	−9	.....	.....	43	+5	.....	.....

VAPOR PRESSURE (*mb.*).

Surface	7.10	+0.62	3.92	+0.48	7.44	+0.10	2.55	+0.06	11.23	+1.78	4.38	+0.32
250	7.07	+0.64	.....	.....	7.35	+0.12	.....	.....	11.04	+1.96	3.52	−0.44
500	6.47	+0.79	3.82	+0.54	6.53	+0.10	2.51	+0.05	10.47	+2.04	2.94	−0.53
750	5.90	+0.79	3.56	+0.58	5.84	−0.10	2.23	−0.02	9.51	+1.74	2.48	−0.66
1,000	5.41	+0.83	3.26	+0.44	5.19	−0.34	2.06	−0.10	8.51	+1.52	2.14	−0.71
1,250	4.77	+0.64	3.10	+0.43	4.67	−0.37	1.90	−0.17	7.89	+1.54	1.93	−0.65
1,500	4.05	+0.41	2.98	+0.46	4.06	−0.52	1.82	−0.13	7.44	+1.66	1.73	−0.61
2,000	2.93	−0.01	2.44	+0.24	3.04	−0.66	1.64	−0.07	6.24	+1.54	1.18	−0.70
2,500	2.16	−0.24	1.91	+0.06	2.07	−0.91	1.38	−0.02	5.31	+1.40	0.95	−0.73
3,000	1.75	−0.22	1.55	−0.01	1.59	−0.87	1.07	−0.02	4.40	+1.21	0.59	−0.88
3,500	1.30	−0.41	1.11	−0.17	1.34	−0.76	0.57	−0.20	3.78	+1.15	0.39	−0.92
4,000	0.93	−0.40	0.56	−0.46	1.02	−0.77	0.33	−0.20	3.29	+1.21	.....	.....
4,500	0.69	−0.47	0.18	−0.64	0.90	−0.75	0.90	+0.18	2.91	+1.14	.....	.....
5,000	.....	.....	.....	.....	0.82	−0.73	.....	.....	2.60	+1.11	.....	.....

TABLE 2.—*Free air, resultant winds, m. p. s. during January, 1923.*

Altitude, m. s. l. (*m.*)	Broken Arrow, Okla. (233*m.*)				Drexel, Nebr. (396*m.*)				Due West, S. C. (217*m.*)				Ellendale, N. Dak. (444*m.*)				Groesbeck, Tex. (141*m.*)				Royal Center, Ind. (225*m.*)			
	Mean.		5-year mean.		Mean.		8-year mean.		Mean.		2-year mean.		Mean.		6-year mean.		Mean.		5-year mean.		Mean.		5-year mean.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 31° W.	2.6	S. 35° W.	1.1	N. 86° W.	1.2	N. 86° W.	1.4	S. 84° W.	2.8	N. 84° W.	1.4	N. 34° W.	1.8	N. 56° W.	2.9	S. 17° W.	2.8	N. 40° W.	0.4	S. 51° W.	1.8	S. 51° W.	2.1
250	S. 30° W.	2.7	S. 31° W.	1.3	.....	.....	.....	.....	S. 82° W.	3.1	N. 86° W.	1.7	.....	.....	.....	.....	S. 19° W.	3.7	N. 63° W.	0.3	S. 51° W.	1.9	S. 51° W.	2.4
500	S. 35° W.	3.7	S. 26° W.	2.3	N. 85° W.	2.1	N. 81° W.	2.4	S. 84° W.	5.5	W.	3.4	N. 40° W.	1.8	N. 58° W.	3.3	S. 29° W.	5.9	S. 58° W.	1.3	S. 57° W.	4.1	S. 59° W.	4.4
750	S. 48° W.	4.0	S. 32° W.	3.3	N. 88° W.	4.2	N. 75° W.	4.2	S. 89° W.	7.4	S. 89° W.	5.1	N. 70° W.	2.3	N. 64° W.	4.9	S. 41° W.	7.0	S. 62° W.	2.5	S. 72° W.	6.2	S. 67° W.	6.6
1,000	S. 58° W.	4.6	S. 46° W.	3.6	N. 81° W.	5.1	N. 75° W.	5.5	S. 88° W.	8.8	S. 87° W.	6.1	N. 81° W.	2.9	N. 64° W.	6.1	S. 46° W.	7.5	S. 62° W.	3.4	S. 80° W.	7.4	S. 77° W.	7.5
1,250	S. 74° W.	4.9	S. 61° W.	3.9	N. 79° W.	6.5	N. 75° W.	6.7	N. 88° W.	10.7	N. 84° W.	8.2	N. 86° W.	3.7	N. 66° W.	7.2	S. 54° W.	8.5	S. 71° W.	4.6	S. 82° W.	9.0	S. 81° W.	8.9
1,500	S. 82° W.	5.2	S. 59° W.	4.9	N. 75° W.	8.9	N. 73° W.	8.2	N. 86° W.	12.5	W.	9.6	N. 85° W.	5.5	N. 66° W.	7.7	S. 52° W.	9.8	S. 74° W.	5.8	S. 82° W.	10.2	S. 85° W.	10.0
2,000	W.	6.9	S. 73° W.	7.0	N. 74° W.	11.2	N. 73° W.	10.5	N. 82° W.	15.2	N. 84° W.	12.0	N. 77° W.	8.8	N. 67° W.	10.1	S. 64° W.	9.3	S. 78° W.	7.4	S. 78° W.	11.4	S. 84° W.	12.0
2,500	S. 86° W.	8.9	S. 82° W.	8.6	N. 81° W.	14.3	N. 79° W.	12.6	N. 86° W.	17.4	N. 85° W.	15.0	N. 76° W.	12.5	N. 66° W.	12.4	S. 75° W.	9.0	S. 80° W.	8.4	N. 88° W.	15.2	W.	14.3
3,000	N. 80° W.	9.1	N. 86° W.	10.4	S. 89° W.	16.0	N. 79° W.	14.4	S. 80° W.	16.7	N. 89° W.	16.5	N. 86° W.	13.0	N. 69° W.	14.0	S. 82° W.	8.8	S. 81° W.	9.8	S. 79° W.	15.8	S. 88° W.	14.2
3,500	W.	10.1	N. 86° W.	10.6	S. 78° W.	16.6	N. 80° W.	15.3	S. 80° W.	15.3	W.	16.2	N. 79° W.	13.6	N. 69° W.	15.1	S. 80° W.	8.9	S. 88° W.	10.4	S. 61° W.	14.0	S. 80° W.	13.3
4,000	S. 80° W.	15.5	S. 86° W.	15.5	S. 68° W.	17.0	N. 88° W.	16.9	S. 85° W.	15.5	N. 83° W.	15.8	N. 68° W.	16.4	N. 60° W.	16.8	W.	11.9	S. 80° W.	11.6	W.	19.7	S. 73° W.	17.7
4,500	W.	10.9	S. 77° W.	13.3	.....	.....	.....	.....	S. 79° W.	16.9	N. 83° W.	15.3	N. 59° W.	18.9	N. 52° W.	19.0	N. 74° W.	12.6	S. 80° W.	12.3	.....	.....	.....	.....
5,000	.....	.....	.....	.....	.....	.....	.....	.....	N. 68° W.	18.6	N. 57° W.	17.8	.....	.....	.....	.....	N. 74° W.	13.6	N. 88° W.	14.5	.....	.....	.....	.....

THE WEATHER ELEMENTS.

By P. C. DAY, Meteorologist, in Charge of Division.

[Weather Bureau, Washington, March 1, 1923.]

PRESSURE AND WINDS.

Like the preceding December, January, 1923, was notable for the disturbed atmospheric conditions. Cyclones and anticyclones, mostly well to the northward of their usual tracks, moved in rapid succession across the country, though the cyclones were usually of little importance until they reached the Atlantic coast districts, after which they frequently developed into severe storms as they moved northeasterly toward the Grand Banks.

The more important anticyclones were of the Hudson Bay type, and while moving into the United States to westward of the Great Lakes usually experienced their greatest development in the St. Lawrence Valley or the northeastern United States.

The absence of important anticyclones that usually move into the United States during midwinter from the far Canadian Northwest was one of the marked features controlling the weather of the month, and the chief factor leading to its moderate character over much of the country. As a result of this absence of important anticyclones in the Northwest, the average sea-level pressure was below normal over the greater part of the country, and notably so in the far Northwest.

In portions of the Southeastern States, and from the upper Lakes eastward to New England and the Canadian Maritime Provinces, the average pressure was somewhat higher than usual in January, and over small areas in the Southwest, and generally in California, pressure for the month was likewise above normal.

The usual trend of the changes in pressure from December to January was likewise greatly disturbed, and the increases commonly found during this month in the great central valleys and northern districts of the United States and throughout the Canadian Provinces were mainly overcome and important negative changes existed instead.

Owing to the disturbed condition of the atmosphere, due to the frequent occurrence and rapid movement of cyclones and anticyclones, the system of winds usual to January was again greatly disturbed, as during the preceding months. However, the winds were mainly from southerly points in the Gulf States and southern Great Plains, and from west to northwest along the northern border, although in a few localities, particularly in the upper Missouri Valley, they were mainly from southerly points. In New England they were largely from the northwest, and that direction prevailed over most of the Middle Atlantic States. In the far West the prevailing winds were greatly diversified, as usual, but they were mainly outward from the region of highest average pressure, which embraced central California and the middle Plateau region.

There was a marked absence of severe storms over most of the country, save in the northeastern coast districts, where the winds attained high velocities on several dates. High winds prevailed locally in southeastern Wyoming on the 3d, attaining a maximum velocity of 82 miles per hour at Cheyenne, the highest ever observed at that station.

TEMPERATURE.

The outstanding feature of the weather during January, 1923, was the almost continuously high temperatures that prevailed during the greater part of the month over much of the country. At the same time, however, severe winter weather was the rule over New England and much of New York, which were the only localities having temperatures below the normal for the month save, in Northern California, where a small area was cooler than normal.

The first decade of the month was unusually warm over all portions of the country, save from the lower Lakes northeastward to New England, where in the main this period was distinctly cold. In the central and western districts the daily averages for this period ranged from 6° to 15° above the normal, and the highest temperatures ever known in January were reported from southern California near the end of the decade.

During the second decade, save for short interruptions, temperatures continued above normal as in the first decade, except that some cold weather for the region prevailed in California, and the averages for the decade were even higher than during that preceding over much of the interior portions of the country, ranging from 15° to 20° above the normal in the Great Plains and upper Missouri Valley. There was a sharp reaction to colder weather, however, about the end in the Dakotas and upper Mississippi Valley. Severe winter weather continued in the Northeastern States throughout the decade, the temperatures reaching unusually low points locally in New England.

The final decade of the month continued cold in New England, and like conditions prevailed during much of the period in the far West. In the districts from the Rocky Mountains eastward, save over the Northeastern States, this decade was likewise warmer than normal, though the departures were mainly less than for the preceding decades.

The month as a whole was among the warmest of record for the midwinter month over large portions of the Great Plains and central valleys, some stations reporting practically every day of the month as warmer than normal

The highest temperatures of the month were not reported from extensive areas on any particular date, but in the main they occurred in the far West during the early part of the month, while in the districts from the Rocky Mountains eastward they occurred generally toward the end of the second and near the beginning of the third decades, except in New England, where the highest temperature of the month occurred on the first.

The lowest temperatures were likewise well scattered through the month, and no extensive regions had the lowest for the month on the same date. Freezing weather was reported from some portion of all the Southern States, but many of the Central Valley States had no temperatures of zero or lower, a condition not experienced in those States during January since State-wide weather records began, nearly 30 years ago.

PRECIPITATION.

Precipitation occurred with unusual frequency, particularly during the first half of the month, in northern districts west of the Continental Divide and from the upper Lakes eastward, as a result of the rapid passage of storm centers which moved eastward mainly over the northern districts and the adjacent parts of Canada. Two of the storms during the first half affected nearly all the districts to eastward of the Plains, the earlier from 7th to 10th, however, not giving much or any rain in the Gulf and South Atlantic districts, but the later, about the 13th to 15th, causing precipitation nearly everywhere save in the Florida Peninsula.

From the middle of the month onward there was considerably less precipitation than before in the far Northwest, the most important wet period coming about the 17th to 19th. An important storm caused much precipitation from the 20th to 22d over the middle Mississippi Valley and districts to northeastward, with especially heavy falls over the Ohio Valley, and shortly afterward a vigorous storm took a more southerly course, from the Texas coast on the 21st northeastward to the New England coast on the 25th, causing decidedly heavy rains in many parts of the Gulf and South Atlantic States and more moderate rains and snows to northward.

Meanwhile, about the 24th, California, Nevada, and Arizona, where the first half of the month had been dry for midwinter, received much rain and snow in connection with a storm which crossed the country not far from the fortieth parallel of latitude, and caused widespread rainfall or snowfall in the eastern half from the 26th to 28th. Another storm caused rain from central Oklahoma and northeastern Texas to the Carolinas and southern Middle Atlantic States just before the end of the month, and at the same time important precipitation occurred again in the far Southwest.

The precipitation for the month was abundant over a narrow strip from north-central Texas northeastward to New England, especially in Arkansas, close to and just south of the Ohio River, and from eastern Pennsylvania over the southern New England States and the coast districts of Maine. To southeastward it was generally less than normal, but was usually ample, save in the Florida Peninsula and parts of southern Georgia. In the Lake region and the north-central portion of the country the precipitation was mainly about normal or somewhat below. From the lower and middle Missouri River and the Black Hills region southwestward to the Mexican border in New Mexico and far western Texas there was decidedly little precipitation, considerable areas reporting none at all. Arizona and California had usually less than normal, the portions which are naturally driest being, as a rule, without precipitation of consequence; but other districts west of the Continental Divide had mainly rather more precipitation than normal, the excess being marked between the Cascade Mountains and the coast.

SNOWFALL.

The snowfall of January was about average in most higher districts of the far West, save to east and south of the Colorado River, and was heavy in the northern portions of the Lakes region, and especially in the Northeast. At Portland, Me., the snowfall for the month was the greatest for any month in more than half a century, and at New Haven the fall was the greatest January amount, with one exception, during a like period, and the average for all the New England States was the greatest in the 35-year period of comparative records.

The southern New England States, southeastern New Hampshire, and southwestern Maine had an unusual accumulation at the end of the month, causing great hindrance to transportation. Most of New York and the northern portions of New Jersey and Pennsylvania had much greater snowfall than the average. The southern Middle Atlantic States had less snow than usual, and this was emphatically the case from northern Ohio, Indiana, and Illinois and southern Iowa southward, also in the middle Plains.

In the Dakotas and at the lower elevations of the far West the snowfall was mainly light, and owing to high temperatures the ground was bare to a greater extent than usual. The high mountains, as a rule, retained a good stored depth and received a considerable addition, resulting in average or better prospects for spring and summer flow in the streams fed by melting snows, save in New Mexico and parts of Arizona and Colorado where the depths are small and the outlook is discouraging.

RELATIVE HUMIDITY.

Over most of the country the average relative humidity was less than normal, the deficiency ranging up to 20 per cent or more in the Great Plains. In North Dakota and thence eastward to the Great Lakes there was a general excess in the percentage, and this was true over New England. There were likewise local areas in the South Atlantic and Gulf States with percentages above normal, as well as in the far West.

SEVERE LOCAL STORMS.

The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau.]

Place.	Date.	Time.	Width of path (yards).	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
Petersburg, Va., and vicinity	1	a. m				Wind	Roof of home blown off, small outhouses blown down, and tobacco houses wrecked.	Times-Dispatch (Richmond, Va.).
New York City	1					Wind and rain	Large glass sign blown down. Store window damaged.	Daily News (New York).
Asheville, N. C	7	9:30 p. m				Thunderstorm	Some damage to telephone lines	Official U. S. Weather Bureau.
Denver, Colo	7- 8					Wind	Roofs torn from buildings, trees and poles down, much damage to light and power lines.	Times (Denver, Colo.).
Fort Collins, Colo	7- 8				$3,000	do	A half-finished house was destroyed and other property damage reported.	Do.
Laramie, Wyo	7- 8			1	2,000	do	Buildings unroofed, chimney and wires blown down.	Do.
Lake Charles, La., and vicinity	22			1	1,000,000	Tornado	Several persons injured and a number of houses wrecked.	Daily News (New York); Times-Herald (Washington, D. C.).
Chattanooga, Tenn., and vicinity	23					Ice	Damage to telephone poles, wires, and timber	Official, U. S. Weather Bureau.
Anniston, Ala., and vicinity	23	a. m				Wind and rain	Windows broken, trees blown down, and traffic held up; 2 persons injured.	Star (Anniston, Ala.).
Georgia	23-24				250,000	Wind and sleet	Communication with outside points hampered; public utilities throughout the State report damage to power plants and wires.	News (Pensacola, Fla.); official, U. S. Weather Bureau.
Abilene, Tex. (25 miles southeast of).	30	p. m	300			Tornado	Residences and outbuildings damaged	Official, U. S. Weather Bureau; Dallas Morning News (Tex.).

STORMS AND WEATHER WARNINGS.

BY EDWARD H. BOWIE, Supervising Forecaster.

January, 1923, was notable for the large number of disturbances which traveled eastward over the United States and southern Canada and also for the rapidity of their movement. The rapid succession of LOWS continued until near the end of the month, or to be specific, until the 26th, when a disturbance of the South Atlantic type moved up the coast, increased greatly in intensity and finally reached Newfoundland where its center remained until the close of the month. During this time, i. e., the 26th to 31st, a notable retardation was noticeable in the speed of the cyclones and anticyclones in the United States. The precise cause of this retardation is not apparent, but seemingly it was connected in some way with the pressure distribution in the vicinity of Greenland, as reports radioed from that region showed abnormally high pressure during this period. The anticyclones of the month traveled with speeds approximating those of the cyclones, and none of these were of the type that normally carries extremely cold weather far to the southward. In fact, nearly all of them moved in relatively high latitudes and the cold waves of the month were confined to the more northern sections of the United States. The prominent feature of the January, 1923, run of weather was the frequent and heavy snowfalls in the North Atlantic States.

WASHINGTON FORECAST DISTRICT.

The month opened with a belt of low pressure on the Atlantic seaboard, with a center of minimum pressure over southern Virginia. As it advanced northeastward, it increased decidedly in intensity and caused general and heavy precipitation in the Middle Atlantic and New England States and gales on the coast north of Delaware Bay. The highest velocity reported was 64 miles from the southeast at Atlantic City, N. J. Following this disturbance, others of more or less marked intensity passed eastward over the Washington District and storm warnings were displayed for them as follows: On the 3d at and between Delaware Breakwater and Eastport, Me.; on the 7th on the Atlantic coast north of Cape Fear, N. C., and on the 8th warnings were continued on the New England coast at and north of New Haven, Conn.; on the 10th at and between Delaware Breakwater and Provincetown, Mass.; on the 11th at and north of the Virginia Capes and for the same coastal region on the 14th and 18th; on the 20th at and north of Sandy Hook, N. J.; on the 23d from Savannah, Ga., to the Virginia Capes and on the 24th for the same storm the warnings were extended northward to Eastport, Me., and continued for the same storm on the 25th for the coastal waters from Sandy Hook northward. This record of necessary storm advices indicates the frequency of storm winds during January on the Atlantic coast, for in practically every instance winds of gale force and, not infrequently, snows accompanied the disturbances for which warnings were issued.

Warnings of frost were issued on a number of days for the South Atlantic and Gulf States, but these regions did not receive the cold weather that normally is to be expected in January. Cold wave warnings were issued on a number of days for the Mississippi and Ohio Valleys, the lower Lake region and the North Atlantic States, but as a matter of fact, the only pronounced cold waves of the month in the Washington Forecast District occurred in the Atlantic States north of Maryland and in the lower Lake region and these were accurately forecast.

The usual amount of forecast and other information was issued for the aid of aviation activities. A notable part of this work was the issue of forecasts and information for a considerable number of seaplanes bound from Hampton Roads, Va., to southern waters. This work was done in cooperation with the United States Navy.

CHICAGO FORECAST DISTRICT.

Except in the northern upper Lake region, January, 1923, was not so cold as usual in the Chicago Forecast District. In fact, over the southern half of the district the month was especially mild, temperatures averaging from 6° to 10° a day above the normal. Frequent precipitation occurred in the Lake region, where scarcely a day passed without some rain or snow being reported; while on the other hand, the weather was exceptionally dry in the Middle Plains States. In southwestern Kansas the lack of moisture was so pronounced that at the close of the month a great deal of ungerminated wheat was still lying in the dust where it has been sown.

Cold-wave warnings.—No general cold-wave warnings were issued during the month, nor were any warnings of this scope required. Except in one instance all warnings were for areas in the northern half of the district, and these were, as a rule, rather limited as to the extent of territory included. Most of the warnings issued were verified in whole or in part, but in a few cases cold waves occurred without warning. This was especially true in the Red River of the North Valley and adjacent territory, where the number of cold waves occurring appears to have been about as large as usual. The following is a summary of the cold-wave warnings issued:

2d: Northwestern Wisconsin and vicinity of Lake Superior in Minnesota.
3d: North Dakota and northwestern Minnesota.
4th: Northern Minnesota.
5th: Upper Michigan, northern lower Michigan, eastern and southern Wisconsin, Missouri, southern and western Illinois, and southern and eastern Iowa.
16th: Extreme northern lower Michigan.
17th: Northeastern Montana, North Dakota, and northern Minnesota.
18th: Minnesota, eastern South Dakota, upper Michigan, lower Michigan, and Wisconsin.
24th: Wisconsin and extreme eastern Minnesota.
28th: Montana, North Dakota, extreme western South Dakota, and Wyoming.
29th: Southern Wyoming, southern and central Minnesota, and eastern South Dakota.
30th: Minnesota, western upper Michigan, and northwestern Wisconsin.

Stock warnings.—The month was especially favorable for live stock in the grazing sections of the Plains States and no losses are known to have occurred as a result of adverse weather conditions. The only warning issued was that on the 29th for South Dakota, Nebraska, and Wyoming.

Advisory warnings for Lake Michigan.—No storms of severity affected Lake Michigan during the month, navigation having been carried on under more favorable conditions than ordinarily is the case in January. In fact, an unusual volume of business was reported as a result of the prevailing mild weather and absence of storms. Advisory warnings were issued on the 6th, 11th, 13th, 17th, 18th, and 23d, but only on the 18th were winds of gale force forecast.

As instances of the appreciation of the press in the efforts of this office toward cooperation the following

quoted letters have been received by Professor Cox. The first is from the superintendent of the central division of the Associated Press, and the other from the managing editor of the Chicago Herald and Examiner.

1. I wish to express my appreciation for the splendid cooperation that we receive from you and the men attached to your bureau. We appreciate not only the prompt service on the regular and the special weather reports, but also the telephone calls on earthquake records and warnings of important weather changes.

2. Thank you very much for your kind letter of January 26, relative to service on weather forecasts for the press. We always knew you were a true friend of the newspapers, as you have proved yourself innumerable times in the past.

—*C. A. Donnel.*

NEW ORLEANS FORECAST DISTRICT.

The weather over this district was exceptionally mild for the month of January. A cold-wave warning was issued for Oklahoma and northwestern Arkansas at 2 p. m. of the 5th and later extended over the remainder of Arkansas. The cold wave occurred as forecast over Oklahoma and northwestern Arkansas. Noon-special observations, January 22, showed a depression over southern Louisiana and a rapid rise in the barometer over the southern Plains States and Texas. Cold-wave warnings were ordered at 1 p. m. of the 22d for southern Texas and southern Louisiana. Verifying temperatures were not reached. Cold-wave warnings were ordered for Oklahoma and the Texas Panhandle on the 31st, and they were justified.

Live-stock warnings were issued for the northern portion of the district on the 5th, 14th, and 22d. Fire-weather warnings were issued on the 5th. "Norther" warnings were issued for Tampico, Mexico, on the 22d.—*I. M. Cline.*

DENVER FORECAST DISTRICT.

From the 1st to the 11th, generally high pressures prevailed west of the Continental Divide, with LOWS from the north Pacific passing to the northward of the district. A LOW which appeared on the Southern Plateau on the 12th advanced northeastward across Colorado, attended by occasional light snow in the northern portions of this State and Utah. High pressures prevailed west of the Divide from the 14th to the 19th. On the morning of the 14th, when the crest of the HIGH was over Utah and moving southeastward, warning of a moderate cold wave was issued for extreme southeastern New Mexico. On the following morning the minimum temperatures at Roswell and Abilene were 28° and 30°, the 24-hour falls at those stations, 14° and 22°, respectively.

A storm of decided intensity appeared on the coast of northern California on the morning of the 22d and advanced slowly to southeastern Colorado and northwestern Texas, where it recurved to the northeastward on the 26th. This disturbance was accompanied by precipitation in about all portions of the district except southern New Mexico, with heavy snow in northwestern and extreme southeastern Utah and in portions of northeastern Arizona and southwestern Colorado.

Another storm of marked energy advanced southward from Alaska during the 27th and 28th and was central over southwestern Utah on the evening of the latter date. On the morning of the 29th the disturbance had increased in intensity and extended eastward to Kansas, but with its center remaining over southern Utah, while a HIGH of great intensity, attended by severely cold weather, was central on the northeastern Rocky Mountain slope. Warnings of a moderate cold wave and live-stock warnings were issued for eastern and extreme northwestern Colorado and southern Utah. Warnings of a moderate cold wave were repeated on the evening of the 29th for northern and eastern Colorado and southeastern Utah. The cold-wave warnings were justified in eastern Colorado, but as the storm center remained nearly stationary over southern Utah, there was little fall in temperature wast of the Divide. Only light snow occurred in northeastern Colorado, Utah, and northern Arizona. Cold-wave warnings were repeated for southwestern Utah on the morning of the 31st. The storm center failed to move, however, and the warning was only partially verified, the fall in temperature at Modena amounting to 12°, with a minimum of 16°.

Frost warnings were issued for southern Arizona on the 1st and 2d and for extreme southwestern Arizona on the 3d, 27th, 28th, 30th, and 31st. Warnings of freezing temperature were issued for south-central and southeastern Arizona on the 2d and 27th and for southeastern Arizona on the 3d. With the exception of the 31st, the warnings were justified.—*J. M. Sherrier.*

SAN FRANCISCO FORECAST DISTRICT.

The outstanding factor of weather control in this district during January, 1923, was the shifting of the Pacific HIGH from California and the Plateau to British Columbia and the adjacent North Pacific. During the first part of the month an area of high pressure was central over California and the Plateau which caused storms from the North Pacific to move inland through British Columbia. On the 15th, a change in the pressure distribution began, the high area moving to British Columbia and the adjacent Pacific while the pressure diminished to normal or below over Calfiornia and the Plateau. This caused storms moveing southeastward from Alaska to pass to the west of the high area in the north and enter the continent through the North Pacific States.

Conformable to a pressure distribution as described the first part of the month was "wet" in the northern portion of this district and "dry" in the southern and the latter part of the month "wet" in the southern portion and comparatively "dry" in the northern.

A warm wave prevailed over southern California on the 8th and 9th, and January records of high temperature were broken at Los Angeles on the 8th, while on the 9th they were broken at San Diego and equaled at San Luis Obispo.

Frost warnings were issued in California on 14 days, and while severe frosts occured at many places, no serious damage was reported.

Storm warnings were ordered as follows: At Washington and Oregon stations, 4 times; at the mouth of the Columbia River, Strait of Fuca, and Washington coast, 5 times; on the California coast, 4 times. The warnings were generally verified.

On the 15th, 16th, 17th, and 18th strong gales were reported from many ships in the Pacific.—*G. H. Willson.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

The principal flood of the month was in the Willamette Valley, and it proved to be the most disastrous one since the great flood of February, 1890. True, the water at Portland, Oreg., was higher in June, 1894, but this flood was caused by back water from the Columbia River and the rise was gradual, while the rise in January, 1923, was rapid and the current swift.

Precipitation was more frequent than usual over western Oregon during December, 1923, and was about 50 per cent in excess of the normal quantity, with a moderate amount of snow in the Cascade Mountains at the end of the month. All streams, which had been unusually low during the fall, were rising. Moderately heavy rains fell during the first four days of January, 1923, and heavy rains on January 5 and 6, accompanied by southwest winds and abnormally high temperatures. The total precipitation at selected stations for the first seven days of January is given in the following table:

	Inches.
Cottage Grove, Oreg.	5.24
Eugene, Oreg.	3.89
Albany, Oreg.	6.39
Detroit, Oreg.	12.70
McMinnville, Oreg.	5.11
Salem, Oreg.	4.98
Portland, Oreg.	4.01
South Fork, Oreg.	6.77

All the rivers of western Oregon were in flood, and the data are given in the table of flood stages. So far as is known no previous records were exceeded, except possibly on the Clackamas River.

The crest stage of 25.3 feet at Portland, Oreg., on January 7, was 3.4 feet below the crest of February 5, 1890, and 7.7 feet below that of June 7, 1894.

At Vancouver, Wash., the Columbia River was above the flood stage of 15 feet from January 7 to 12, inclusive, with a crest stage of 19 feet on January 10. This rise was due almost entirely to back water from the Willamette flood.

Flood warnings were issued on January 6, and daily thereafter until the water subsided.

The total loss and damage reported was $171,702, of which $125,112 was in buildings, etc. Crop losses were small, but suspension of business caused a loss of $37,310. The value of property reported as saved by the warnings was $133,050. The Southern Pacific Railroad Co., was the heaviest loser on account of damage to bridges and tracks.

Moderately high water prevailed in the Santee River of South Carolina throughout the month, but there was no damage of consequence. The heavy rains of January 22, also caused moderate floods in the Oconee and Ocmulgee Rivers of Georgia, but an ice storm interupted communication, delaying the receipt of reports and the issue of warnings. However the warnings were in time to prevent damage.

Moderate flood stages also prevailed in the Apalachicola River of Florida a few days later.

The floods in the Black Warrior and lower Tombigbee Rivers of Alabama, and in the Pearl River at Jackson, Miss., were likewise unimportant. They were properly forecast, and no damage was reported.

The Ohio River, between Evansville, Ind., and Henderson, Ky., reached the flood stages of 35 and 33 feet, respectively, on January 30, and the river continued to rise at the close of the month. Warnings were first issued on January 27.

Green River of Kentucky responded quickly to the rains of January 20 and 24, and was generally in flood, beginning with January 23. At Lock 4, Woodbury, Ky., the crest stage of 41.3 feet on January 26, was 8.3 feet above the flood stage, while at Lock No. 2, Rumsey, Ky., the crest of 39 feet was 5 feet above the flood stage. Warnings were first issued on January 22, and there was no damage of consequence.

Snowfall.—At the close of the month the depth of snow over the drainage area of the Connecticut River ranged from 16 to 40 inches with an average of about 25 inches. The maximum depth of 40 inches was reported at Bellows Falls, Vt., and the minimum of 16 inches near headwaters. Approximately similar conditions prevailed over the Hudson River drainage area, while over the upper Susquehanna district the amount of accumulated snow was about one-third less. There were also several inches of snow over the mountain tributary districts of the upper Ohio River.

NOTES.—The following changes were made, effective January 1, 1923:

Louisville, Ky.: Lower gage readings discontinued December 31, 1922, and readings from new gage, about 75 feet below, begun on January 1, 1923. The zero of the new gage is 4.1 feet lower than that of the old gage.

New Orleans, La.: Readings from Weather Bureau gage at foot of Canal Street, discontinued December 31, 1922, and readings of the United States engineer gage at Carrollton, 7½ miles above, begun on January 1, 1923. Relations between the two gages are as follows:

From— Canal Street.		Carrollton.
0 to 1 foot	subtract	2.9 feet.
1 to 2 feet	do	2.7 feet.
2 to 3 feet	do	2.6 feet.
3 to 4 feet	do	2.5 feet.
4 to 5 feet	do	2.4 feet.
5 to 6 feet	do	2.4 feet.
6 to 7 feet	do	2.3 feet.
7 to 8 feet	do	2.2 feet.
8 to 9 feet	do	2.2 feet.
9 to 10 feet	do	2.1 feet.
10 to 11 feet	do	2.0 feet.
11 to 12 feet	do	1.8 feet.
12 to 13 feet	do	1.7 feet.
13 to 14 feet	do	1.6 feet.
14 to 15 feet	do	1.5 feet.
15 to 16 feet	do	1.4 feet.
16 to 17 feet	do	1.3 feet.
17 to 18 feet	do	1.2 feet.
18 to 19 feet	do	1.1 feet.
19 to 20 feet	do	1.0 feet.
20 to 21 feet	do	0.9 feet.

The river district of Asheville, N. C., was abolished on December 31, 1922, and the territory thereof absorbed in the Knoxville, Tenn., district, which now comprises the entire drainage area of the Tennessee River above Knoxville, Tenn.

Flood stages during January, 1923.

River and station.	Flood stage.	Above flood stages—dates. From—	To—	Crest. Stage.	Date.
ATLANTIC DRAINAGE.					
Santee:	*Feet.*			*Feet.*	
Rimini, S. C.	12	3	8	13.2	5-6
Do.	12	12	12	12.4	12
Do.	12	26	30	13.1	29
Ferguson, S. C.	12	4	14	12.9	8
Do.	12	28	(1)	12.5	30-31
Oconee:					
Milledgeville, Ga.	22	24	25	23.2	25
Ocmulgee:					
Macon, Ga.	18	24	24	18.0	24
Abbeville, Ga.	11	31	(1)	11.4	31
EAST GULF DRAINAGE.					
Apalachicola:					
River Junction, Fla.	12	27	27	12.1	27
Blountstown, Fla.	15	26	31	16.5	27
Tombigbee:					
Lock No. 4, Demopolis, Ala.	39	25	(1)	47.1	29
Black Warrior:					
Lock No. 10, Tuscaloosa, Ala.	46	24	25	47.0	24
Pearl:					
Jackson, Miss.	20	25	(1)	22.5	30
MISSISSIPPI DRAINAGE.					
Ohio:					
Evansville, Ind.	35	30	(1)	36.2	31
Henderson, Ky.	33	30	(1)	33.5	31
Green:					
Lock No. 6, Ky.	30	24	26	31.7	25
Lock No. 4, Ky.	33	23	(1)	41.3	26
Lock No. 2, Ky.	34	26	(1)	39.0	31
Black:					
Black Rock, Ark.	14	22	27	16.7	23
Do.	14	31	(1)	16.0	31
Cache:					
Patterson, Ark.	9	29	(1)	10.2	31
Sulphur:					
Ringo Crossing, Tex.	20	31	31	20.1	31
COLUMBIA BASIN DRAINAGE.					
Columbia:					
Vancouver, Wash.	15	7	12	19.0	10
Willamette:					
Eugene, Oreg.	10	1	1	11.2	1
Do.	10	6	9	18.0	7
Albany, Oreg.	20	7	10	30.0	8
Salem, Oreg.	20	7	10	31.0	8
Oregon City, Oreg.	12	2	13	19.2	9
Portland, Oreg.	15	7	13	25.3	9
McKenzie:					
Hendricks Bridge, Oreg.	14	7	7	14.4	7
Santiam:					
Jefferson, Oreg.	10	6	9	18.5	7
Yamhill:					
McMinnville, Oreg.	35	6	10	43.1	7
Clackamas:					
South Fork, Oreg.	12	5	11	[2] 23.5	7

[1] Continued into February.
[2] Said to have been higher.

MEAN LAKE LEVELS DURING DECEMBER, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., January 6, 1923.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.* Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during December, 1922:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.08	579.15	571.13	244.64
Above or below—				
Mean stage of November, 1922	−0.27	−0.39	−0.28	−0.51
Mean stage of December, 1921	+0.09	−0.39	−0.58	−0.19
Average stage for December, last 10 years	−0.30	−1.02	−0.70	−0.89
Highest recorded December stage	−1.05	−3.43	−2.40	−2.97
Lowest recorded December stage	+0.88	+0.15	+0.27	+1.21
Average relation of the December level to—				
November level	.....	−0.20	−0.20	−0.20
January level	.....	+0.20	+0.10	0.00

* Lake St. Clair's level: In December, 574.12 feet.

MEAN LAKE LEVELS DURING JANUARY, 1923.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., February 5, 1923.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.* Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during January, 1923:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.86	579.02	571.17	244.50
Above or below—				
Mean stage of December, 1922	−0.22	−0.13	+0.04	−0.14
Mean stage of January, 1922	+0.27	−0.29	−0.33	−0.23
Average stage for January, last 10 years	−0.26	−0.99	−0.58	−0.99
Highest recorded January stage	−0.92	−3.65	−2.38	−3.10
Lowest recorded January stage	+0.98	−0.06	+0.21	+0.70
Average relation of the January level to—				
December, 1922, level	.....	−0.10	0.00	+0.10
February, 1923, level	.....	0.00	+0.10	0.00

*Lake St. Clair's level: In January, 573.70 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS: JANUARY, 1923.

By J. WARREN SMITH, Meteorologist.

January, 1923, was unusually favorable for outdoor operations in nearly all sections of the country as the weather was generally mild for the season except in the more Northeastern States. It was especially warm throughout the month in the central trans-Mississippi States and lower Great Plains where the monthly mean temperatures were 10° or more above normal. Considerable rain fell from the lower Mississippi Valley northeastward and precipitation was slightly above normal in the extreme upper Mississippi Valley, the northwestern Lake region, the central Plateau districts of the West, and along the north Pacific coast. Rainfall was very light in the extreme Southeast and in the southern Great Plains, considerable sections of the latter area receiving practically none. Heavy snowfall occurred in the central Plateau districts, and the Northeast from northern Pennsylvania and northern New Jersey northeastward.

Wheat fields were bare of snow throughout the month in the principal winter wheat belt, except for a light covering in the northern portion. Owing to continued mild weather, however, wheat suffered no material damage and remained in satisfactory condition, except where drought persisted in the western portion of the belt. The crop was in uncertain condition in western Kansas, as much of it had not come up and deterioration was reported in central and western Oklahoma and northwestern Texas because of lack of moisture. The snowfall was beneficial for winter grains in the central Plateau districts of the west and in the far Northwest, while the fields were amply protected by snow in the more northern States. Conditions were generally favorable for winter grains in the south Atlantic and east Gulf districts. Some spring oats were seeded as far north as southeastern Kansas near the close of the month.

The weather was favorable for the growth of truck crops in California and the Gulf coast sections, except that there was a lack of moisture in parts of Texas. Some frost damage occurred locally in the interior of Florida on the 17th, and part of the month was rather too dry for truck in portions of that State. Conditions were favorable for handling and marketing tobacco in the Ohio Valley and South Atlantic States. At the close

of the month potatoes were coming up in the Hastings district of Florida and potatoes and early vegetables were being planted as far north as Arkansas.

The unusually mild weather produced conditions favorable for stock quite generally but at the same time there was a continued lack of moisture for ranges from eastern Colorado and western Kansas southward. There was enough moisture the latter part of the month to benefit ranges in southern New Mexico and the rain and heavy snow at higher altitudes were helpful in northern Arizona. The deep snow caused heavy feeding in Nevada.

The weather was generally favorable for fruit and there was no material frost damage. Peach trees were blooming in southern Texas at the close of the month and colder weather was needed in southern districts to check premature development.

CLIMATOLOGICAL TABLES.[1]

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, January, 1923.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	52.0	+5.9	Auburn	81	21	2 stations	23	[2] 4	3.99	−0.89	Fayette	6.51	Tuskegee	1.37
Alaska														
Arizona	47.2	+4.0	2 stations	87	[2] 8	Williams	−5	28	0.66	−0.74	Fort Valley	2.59	4 stations	0.00
Arkansas	48.6	+7.7	Portland	80	14	Evening Shade	15	23	5.78	+1.55	Texarkana	9.71	Booneville	1.75
California	45.4	−0.4	Riverside	94	8	Madeline	−27	31	3.39	−2.10	Crescent City	12.46	2 stations	0.00
Colorado	29.5	+5.8	Canon City	79	18	2 stations	−32	6	0.51	−0.43	Crested Butte	3.04	16 stations	0.00
Florida	61.7	+2.6	Orlando	88	29	Garniers	27	[2] 5	1.75	−1.05	Fenholloway	6.09	Homestead	0.08
Georgia	51.3	+4.5	4 stations	81	[2] 22	Clayton	18	23	4.01	+0.07	Marshallville	7.41	St. Georges	0.62
Hawaii														
Idaho	28.3	+4.4	Lewiston	61	7	Obsidian	−30	29	2.56	+0.36	Wallace	10.00	Murphy	0.38
Illinois	33.8	+7.3	Carbondale	70	18	3 stations	5	[2] 10	1.74	−0.70	Cairo	7.01	Beardstown	0.57
Indiana	33.8	+5.2	2 stations	64	18	2 stations	4	[2] 10	2.92	−0.27	Rome	6.32	La Porte	0.60
Iowa	26.7	+8.8	do	58	17	do	−10	28	0.85	−0.20	Guthrie Center	2.34	Thurman	T.
Kansas	38.5	+8.6	do	79	17	do	5	[2] 22	0.13	−0.55	Pittsburg	1.99	19 stations	0.00
Kentucky	41.0	+5.8	do	68	[2] 11	Berea	11	17	6.11	+1.72	Bowling Green	8.94	Farmers	3.99
Louisiana	58.0	+6.8	6 stations	82	[2] 13	Minden	25	[2] 1	4.21	−0.34	Lakeside	12.94	Angola	1.15
Maryland-Delaware	34.8	+2.3	Cambridge, Md	68	21	Oakland, Md	0	17	4.20	+0.92	Grantsville, Md	6.14	Keedysville, Md	2.49
Michigan	21.3	+1.8	Houghton Lake	49	18	Humboldt	−25	23	1.82	−0.10	Grand Marais	6.56	Mount Clemens	0.55
Minnesota	12.5	+4.6	2 stations	49	[2] 6	Warroad	−39	5	0.97	+0.21	Colquet	2.48	Crookston	0.09
Mississippi	53.3	+6.5	Waynesboro	82	31	Austin	23	1	4.47	−0.47	Merrill	6.53	Fruitland Park	1.73
Missouri	39.2	+8.5	Hollister	75	18	Bethany (2)	3	[2] 6	2.72	+0.46	Vanduser	7.55	Oregon	0.12
Montana	25.4	+6.3	Roundup	70	[2] 21	2 stations	−31	[2] 30	1.20	+0.01	Heron	7.50	4 stations	T.
Nebraska	31.2	+9.1	Purdum	72	17	3 stations	−8	[2] 27	0.35	−0.21	Arden	1.51	do	0.00
Nevada	33.8	+3.8	Las Vegas	79	14	Rye Patch	−9	31	0.82	−0.27	McGill	2.11	Las Vegas	0.07
New England	18.3	−2.6	3 stations	55	1	Pittsburg, N. H	−38	18	5.56	+2.22	Kingston, R. I	8.97	Burlington, Vt	2.42
New Jersey	30.1	+0.2	Long Branch	66	21	Layton	−14	31	5.22	+1.57	Ridgefield	7.26	Pleasantville	3.41
New Mexico	38.8	+4.8	Artesia	82	11	Dulce	−24	28	0.33	−0.32	Batemans Ranch	1.82	40 stations	0.00
New York	20.7	−2.2	2 stations	54	[2] 1	Indian Lake	−36	7	4.39	+1.43	Scarsdale	9.76	Utica	1.54
North Carolina	44.0	+2.8	Smithfield	78	21	Parker	9	17	3.77	−0.07	Bryson City	6.72	Altapass	0.96
North Dakota	10.1	+5.2	Hettinger	56	9	Pembina	−35	5	0.53	−0.01	Forman	1.36	Parshall	0.00
Ohio	32.5	+4.1	Chilo	64	[2] 1	Milfordton	−4	17	3.46	+0.44	Green	6.17	Bowling Green	1.39
Oklahoma	47.5	+9.1	Woodward	83	17	Beaver	9	28	2.00	+0.80	Muskogee	6.23	9 stations	0.00
Oregon	36.3	+3.0	Pilot Rock	76	10	Fremont	−23	31	6.08	+1.65	Cascade Locks	24.92	Vale	0.29
Pennsylvania	29.1	+1.2	Marcus Hook	62	21	Hawley	−17	31	4.26	+0.82	Elk Lick	7.74	Ansonia	1.91
Porto Rico	72.4	−0.8	Utuado	93	29	Aibonito	46	5	2.81	−0.89	Comerio Falls	6.70	2 stations	0.00
South Carolina	49.0	+3.6	3 stations	80	[2] 21	Santuck	20	17	2.74	−0.72	Gaston Shoals	4.77	St. George	0.87
South Dakota	23.1	+7.9	Wagner	66	17	Pollock	−20	31	0.49	−0.05	Waters Ranch	2.58	2 stations	0.05
Tennessee	44.4	+5.5	Newport	72	21	2 stations	17	[2] 13	6.19	+1.19	Dover	8.73	Franklin	4.27
Texas	56.4	+8.0	2 stations	93	[2] 7	Clint	7	3	1.88	+0.13	Mount Pleasant	11.30	13 stations	0.00
Utah	31.6	+5.7	Springdale	70	[2] 9	Pine View	−12	15	1.42	−0.07	Park City	6.29	Lemay	T.
Virginia	38.7	+2.6	Cape Henry	74	21	Mount Weather	7	17	3.55	+0.25	Mendota	7.33	Langley Field	1.57
Washington	34.6	+4.4	Quilcene	69	16	Snyders Ranch	−18	30	6.96	+2.18	Wind River	31.88	Wahluke	0.18
West Virginia	35.2	+3.0	2 stations	68	[2] 7	Cheat Bridge	−2	17	4.46	+0.64	Parsons	7.60	Upper Tract	1.13
Wisconsin	18.2	+4.3	Sheboygan	47	18	3 stations	−27	[2] 6	1.38	+0.11	Port Washington	2.65	Mondovi	0.47
Wyoming	25.5	+5.8	Echeta	67	17	2 stations	−23	[2] 13	0.73	−0.13	Dutch Joe	4.73	4 stations	0.00
Porto Rico [3]	74.0	−0.6	San German	94	4	Jayuya	51	30	8.83	+4.21	Comerio Falls	21.40	Portola	0.15

[1] For description of tables and charts, see REVIEW, July, 1922, pp. 384-385.

[2] Other dates also.

[3] Late report, December, 1922.

TABLE I.—*Climatological data for Weather Bureau stations, January, 1923.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F*	° *F.*		° *F*	° *F.*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles.*							*0–10*	*In.*	*In.*
New England.							**22.2**	**−2.1**											**76**	**5.59**	**+2.1**									**6.6**		
Eastport	76	67	85	29.89	29.98	−.02	17.2	−3.2	46	1	25	−6	7	10	35	16	12	76	4.95	+1.1	16	13,031	nw.	58	ne.	8	10	6	15	6.3	36.0	11.8
Greenville, Me	1,070	6	....	28.81	30.04	.....	8.7	.....	42	1	18	−21	18	−1	44	.....	.....	.....	.....	4.58	.....	15	.....	nw.	.....	.....	.....	10	6	15	.....	40.4	29.0
Portland, Me	103	82	117	29.92	30.05	.00	19.3	−3.1	46	1	27	−3	7	12	38	17	13	75	8.55	+4.7	17	8,156	nw.	38	nw.	25	8	7	16	6.4	52.7	37.7
Concord	288	70	79	29.71	30.04	−.01	19.6	−2.0	49	1	28	−9	24	11	43	.....	.....	.....	.....	3.78	+0.4	14	4,399	nw.	31	nw.	25	11	7	13	5.8	33.2	30.0
Burlington	404	11	48	29.62	30.10	+.05	12.6	−3.7	42	1	22	−19	7	3	42	.....	.....	.....	.....	2.42	+0.6	13	8,508	n.	68	s.	18	7	6	18	7.2	22.9	8.5
Northfield	876	12	60	29.09	30.09	+.04	10.7	−4.4	46	21	23	−25	7	−2	52	10	8	86	3.41	+0.9	13	5,479	n.	40	s.	18	6	6	19	7.2	32.5	21.6
Boston	125	115	188	29.89	30.03	−.02	27.0	−0.9	55	1	34	5	18	20	37	24	18	70	6.07	+2.2	16	8,596	nw.	42	ne.	8	8	5	18	6.7	28.0	7.6
Nantucket	12	14	90	29.99	30.00	−.04	31.4	−0.7	52	1	37	13	30	26	22	29	25	81	4.75	+1.3	16	13,948	nw.	63	ne.	4	8	3	20	7.0	9.9	T.
Block Island	26	11	46	29.99	30.02	−.05	29.7	−1.3	53	1	36	13	30	23	28	28	25	80	5.43	+1.6	14	17,716	nw.	58	nw.	13	6	7	18	6.8	11.9	1.0
Providence	160	215	251	29.85	30.04	−.02	25.8	−1.4	52	1	33	5	18	18	36	23	18	72	6.55	+2.2	16	11,071	nw.	54	nw.	25	8	10	13	6.2	25.4	4.0
Hartford	159	122	140	29.88	30.06	−.01	24.6	−0.9	53	1	32	−1	18	17	39	22	17	74	7.77	+3.9	17	5,671	nw.	39	nw.	1	8	3	20	7.1	40.1	17.4
New Haven	106	74	153	29.94	30.07	−.01	26.5	−1.7	53	1	34	3	18	20	36	24	19	73	7.80	+3.9	14	7,782	ne.	34	n.	13	9	6	16	6.3	31.2	8.5
Middle Atlantic States.							**33.6**	**+1.7**											**74**	**3.84**	**+0.6**									**7.0**		
Albany	97	102	115	29.99	30.10	+.03	19.6	−3.5	46	1	28	−6	31	12	36	18	15	82	4.65	+2.1	16	6,033	nw.	42	s.	18	8	5	18	7.0	34.6	13.6
Binghamton	871	10	84	29.08	30.04	−.04	23.1	0.0	44	1	31	−11	31	15	42	.....	.....	.....	.....	3.48	+1.5	18	4,922	nw.	24	nw.	16	3	4	24	8.5	28.1	8.0
New York	314	414	454	29.71	30.07	−.03	31.0	+0.1	53	1	38	10	18	24	30	28	22	69	5.97	+2.2	15	14,756	nw.	70	nw.	13	5	10	16	6.9	21.8	1.5
Harrisburg	374	94	104	29.69	30.11	+.01	31.2	+2.5	47	1	37	13	17	26	24	28	23	73	3.14	+0.3	12	5,799	w.	30	nw.	28	5	4	22	7.5	9.3	3.0
Philadelphia	117	123	190	29.97	30.10	−.01	34.4	+1.8	59	21	40	14	18	28	28	31	25	68	4.78	+1.4	12	8,391	nw.	34	nw.	1	4	9	18	7.3	4.1	1.5
Reading	325	81	98	29.72	30.09	.....	31.1	.....	52	1	37	12	31	26	27	29	25	76	3.52	0.0	15	5,333	nw.	36	nw.	25	5	7	19	7.5	14.1	1.8
Scranton	805	111	119	29.19	30.09	.00	26.8	+1.3	49	1	33	0	31	20	30	25	22	81	4.24	+1.4	17	5,263	nw.	31	w.	12	4	5	22	8.1	23.4	7.5
Atlantic City	52	37	172	30.02	30.08	−.03	35.6	+3.1	53	1	42	15	17	29	25	33	29	77	4.08	+0.7	11	14,792	nw.	72	se.	24	6	12	13	6.2	4.1	T.
Cape May	18	13	49	30.10	30.12	.00	35.6	+1.5	55	21	41	16	18	30	25	33	30	79	3.44	+0.1	11	7,480	nw.	41	s.	1	7	5	19	6.9	1.1	0.0
Sandy Hook	22	10	55	30.04	30.06	.....	31.4	.....	54	21	36	15	18	26	25	29	24	73	5.44	.....	14	13,583	nw.	50	ne.	8	6	7	18	6.7	10.9	1.0
Trenton	190	159	183	29.86	30.08	.....	31.0	.....	56	21	38	11	17	25	31	28	23	73	4.13	+1.0	12	9,264	nw.	44	nw.	1	5	7	19	7.2	12.8	1.5
Baltimore	123	100	113	29.97	30.10	−.02	36.6	+2.8	64	21	43	20	17	30	25	32	27	69	4.14	+0.9	13	4,732	nw.	21	w.	16	4	13	14	7.0	6.0	0.0
Washington	112	62	85	29.98	30.11	−.02	36.8	+3.4	65	21	43	19	17	30	25	32	26	68	4.24	+0.9	12	6,052	nw.	35	nw.	12	5	8	18	7.1	3.1	0.0
Lynchburg	681	153	188	29.35	30.12	−.01	39.8	+2.3	65	21	49	19	11	31	34	34	28	67	2.25	−1.5	12	6,448	nw.	37	sw.	14	7	10	14	6.4	2.7	0.0
Norfolk	91	170	205	30.02	30.12	−.01	43.9	+3.3	72	21	52	23	17	36	28	39	33	72	1.74	−1.6	9	11,226	ne.	48	w.	16	11	7	13	5.9	T.	0.0
Richmond	144	11	52	29.96	30.12	−.01	40.1	+2.1	68	21	49	21	11	31	30	35	31	75	4.61	+1.6	13	5,856	ne.	37	sw.	14	9	9	13	6.2	0.5	0.0
Wytheville	2,304	49	55	27.68	30.13	−.01	36.4	+3.4	60	21	44	17	17	29	28	32	27	75	3.07	−1.2	16	5,728	w.	29	nw.	15	10	8	13	5.8	6.0	0.0
South Atlantic States.							**50.0**	**+4.0**											**75**	**2.74**	**−0.9**									**5.1**		
Asheville	2,255	70	84	27.73	30.15	.00	41.8	+6.4	63	31	51	21	17	33	31	36	29	68	2.03	−0.8	11	7,772	nw.	34	nw.	9	6	14	11	6.1	1.0	0.0
Charlotte	779	55	62	29.28	30.14	−.01	44.6	+3.4	67	21	53	26	24	36	30	38	33	76	3.67	−0.6	12	4,647	sw.	30	w.	12	8	11	12	5.9	0.0	0.0
Hatteras	11	12	11	30.10	30.11	−.03	48.4	+1.3	66	21	54	30	18	42	25	45	42	82	4.04	−0.9	10	11,302	ne.	44	n.	22	10	11	10	5.3	0.0	0.0
Manteo	12	5	42	.....	.....	.....	45.4	.....	69	21	...	28	14	...	28	.....	.....	.....	4.62	.....	4	.....	sw.	.....	.....	.....	17	6	8	.....	0.0	0.0
Raleigh	376	103	110	29.72	30.14	+.01	44.0	+3.6	71	21	52	24	11	35	36	40	36	78	3.11	−0.4	10	6,954	sw.	56	s.	1	7	11	13	6.3	0.0	0.0
Wilmington	78	81	91	30.07	30.16	+.02	50.2	+3.7	74	22	59	30	18	41	34	45	41	78	3.22	−0.3	8	5,910	w.	32	ne.	22	17	7	7	4.2	0.0	0.0
Charleston	48	11	92	30.10	30.15	.00	53.7	+3.8	76	22	62	38	18	46	27	48	44	79	2.21	−1.2	7	7,779	w.	44	ne.	22	11	13	7	4.7	0.0	0.0
Columbia, S. C	351	41	57	29.77	30.16	+.01	50.6	+5.5	74	21	60	31	23	41	31	43	37	69	2.54	−0.8	6	5,850	s.	28	ne.	22	14	10	7	4.5	0.0	0.0
Due West	711	10	55	29.38	30.17	.....	47.0	.....	71	22	57	29	23	37	32	.....	.....	.....	3.12	.....	9	6,868	sw.	34	nw.	9	11	9	11	5.3	T.	0.0
Greenville, S. C	1,039	113	122	29.01	30.12	.....	45.6	.....	67	28	54	27	23	37	28	39	33	71	2.68	.....	10	6,567	ne.	42	nw.	16	11	7	13	5.5	0.0	0.0
Augusta	180	62	77	29.95	30.15	−.01	51.4	+4.4	75	22	62	31	11	40	33	45	41	77	2.72	−1.4	7	4,379	nw.	27	nw.	9	11	12	8	4.9	0.0	0.0
Savannah	65	150	194	30.09	30.16	+.01	55.6	+4.2	80	22	65	36	4	46	30	48	44	76	2.45	−0.7	5	9,649	s.	44	nw.	9	17	8	6	4.2	0.0	0.0
Jacksonville	43	269	245	30.12	30.17	+.02	59.2	+3.8	79	22	68	38	4	51	25	52	49	78	1.37	−1.8	7	8,716	sw.	39	sw.	1	17	7	7	4.0	0.0	0.0
Florida peninsula.							**67.4**	**+1.8**											**79**	**0.49**	**−2.2**									**3.6**		
Key West	22	10	64	30.10	30.12	+.02	70.5	+1.0	81	8	76	57	11	65	14	65	64	86	0.35	−1.6	5	6,927	ne.	37	w.	9	20	10	1	2.9	0.0	0.0
Miami	25	71	79	30.13	30.16	.....	68.8	+1.5	80	9	75	43	17	62	25	62	59	76	0.21	−3.2	5	6,011	e.	25	n.	16	12	17	2	4.1	0.0	0.0
Sand Key	23	39	72	30.12	30.15	+.05	70.8	.....	78	7	74	60	16	68	11	65	62	75	0.27	.....	4	11,193	ne.	43	ne.	16	19	11	1	3.2	0.0	0.0
Tampa	35	79	92	30.13	30.17	+.05	63.0	+2.9	81	31	71	43	11	55	25	56	53	78	0.90	−1.9	4	3,936	e.	21	nw.	9	16	9	6	4.3	0.0	0.0
East Gulf States.							**54.6**	**+6.7**											**77**	**3.48**	**−1.5**									**4.9**		
Atlanta	1,174	190	216	28.89	30.15	.00	48.2	+5.6	69	27	57	29	4	40	25	44	40	78	1.94	−3.4	11	9,680	nw.	48	nw.	9	14	5	12	5.1	0.1	0.0
Macon	370	78	87	29.76	30.16	.00	51.4	+5.8	73	21	62	30	5	40	33	44	39	71	3.71	−1.5	9	4,788	nw.	25	ne.	23	12	7	12	5.0	0.0	0.0
Thomasville	273	49	58	29.87	30.17	+.01	56.8	+5.8	78	30	67	33	26	46	30	50	46	77	3.94	−0.2	7	3,441	sw.	21	w.	9	10	15	6	4.7	0.0	0.0
Apalachicola	36	42	49	30.13	30.18	.....	57.6	.....	74	28	64	40	4	51	23	54	51	83	3.80	.....	6	4,932	se.	27	nw.	9	19	6	6	3.8	0.0	0.0
Pensacola	56	149	185	30.10	30.16	+.02	58.8	+6.3	72	12	65	37	4	53	22	55	52	82	3.07	−1.0	6	9,378	s.	45	s.	23	11	10	10	5.0	0.0	0.0
Anniston	741	9	57	29.36	30.18	+.02	49.4	+7.2	74	27	60	27	4	39	34	.....	.....	.....	2.84	−2.5	8	4,914	nw.	36	e.	23	10	12	9	5.3	0.0	0.0
Birmingham	700	11	48	29.39	30.17	+.01	51.8	+6.5	73	27	61	28	4	43	29	45	39	69	3.82	−1.5	10	6,174	s.	29	e.	23	14	7	10	4.8	0.0	0.0
Mobile	57	125	161	30.09	30.15	.00	58.4	+6.2	76	12	66	38	4	50	26	53	50	81	2.65	−2.2	6	7,037	se.	32	n.	15	10	15	6	5.2	0.0	0.0
Montgomery	223	100	112	29.92	30.18	+.02	54.6	+6.4	77	27	64	34	4	45	29	48	43	71	3.54	−1.6	8	5,208	s.	27	e.	23	11	12	8	4.5	0.0	0.0
Corinth	469	6	....	.....	.....	.....	48.4	.....	68	7	58	28	25	39	34	.....	.....	.....	5.16	.....	12	.....	s.	.....	.....	.....	5	14	12	.....	0.0	0.0
Meridian	375	85	93	29.74	30.15	−.01	54.2	+9.2	75	30	64	29	4	44	32	48	43	75	2.77	−2.8	8	4,518	sw.	26	ne.	22	12	8	11	5.2	0.0	0.0
Vicksburg	247	65	73	29.87	30.16	+.01	56.2	+8.0	76	7	65	35	25	48	27	51	48	81	4.76	−0.9	11	5,883	s.	30	w.	14	10	8	13	5.5	0.0	0.0
New Orleans	53	76	84	30.10	30.16	+.03	61.0	+6.8	79	31	69	40	25	53	24	54	51	78	5.26	+0.6	8	4,778	s.	26	w.	2	14	7	10	4.8	0.0	0.0
West Gulf States.							**56.7**	**+10.2**											**74**	**3.48**	**+0.3**									**5.0**		
Shreveport	249	77	93	29.84	30.12	−.02	55.9	+9.7	75	30	65	34	23	46	30	50	45	74	4.32	−0.1	8	5,938	s.	30	ne.	22	14	3	14	5.3	0.0	0.0
Bentonville	1,303	11	44	.....	.....	.....	45.4	+11.3	67	11	56	23	3	35	30	.....	.....	.....	5.49	.....	8	.....	.....	.....	.....	.....	14	6	11	.....	T.	0.0
Fort Smith	457	79	94	29.59	30.08	−.06	48.8	+10.5	70	18	59	29	6	39	33	42	35	67	3.62	+1.1	11	6,370	e.	38	sw.	5	11	8	12	5.5	T.	0.0
Little Rock	357	136	144	29.70	30.09	−.06	49.7	+8.3	68	10	59	31	23	41	34	45	40	75	7.42	+2.6	10	7,191	s.	44	s.	5	11	6	14	5.7	0.0	0.0
Brownsville	57	4	26	30.01	30.07	.....	67.6	.....	85	7	76	42	23	59	25	61	59	86	0.13	.....	7	7,257	s.	33	s.	26	14	12	5	4.1	0.0	0.0
Corpus Christi	20	11	73	30.07	30.09	−.01	65.0	+11.5	84	7	72	40	4	58	29	59	56	81	0.40	−1.8	4	9,920	s.	36	n.	22	9	13	9	5.4	0.0	0.0
Dallas	512	109	117	29.52	30.08	.....	55.4	.....	80	18	66	31	3	57	37	.....	.....	.....	4.04	.....	9	6,849	s.	37	ne.	21	14	5	12	5.1	0.3	0.0
Fort Worth	670	106	114	29.34	30.06	−.06	55.5	+11.2	80	18	66	30	23	44	35	47	40	63	4.60	+3.7	6	7,433	s.	35	s.	20	15	5	11	4.8	1.0	0.0
Galveston	54	106	114	30.07	30.13	.00	62.0	+8.2	73	7	67	40	23	45	26	58	56	84	6.99	+3.4	5	8,645	se.	36	nw.	22	14	8	9	4.7	0.0	0.0
Groesbeck	461	11	56	29.58	30.07	.....	57.0	.....	78	20	68	29	3	46	38	.....	.....	.....	1.74	.....	9	9,241	s.	41	sw.	18	13	7	11	5.0	0.0	0.0
Houston	138	111	121	29.96	30.11	.....	62.1	+9.2	79	12	71	37	24	53	30	.....	.....	.....	1.31	.....	7	6,756	s.	38	se.	22	10	12	9	4.7	0.0	0.0
Palestine	510	64	72	29.56	30.10	−.02	58.1	+9.9	79	8	68	33	23	48	33	51	44	67	3.12	−0.8	7	6,890	s.	30	ne.	22	10	9	12	5.5	0.0	0.0
Port Arthur	34	58	66	30.07	30.11	.....	60.6	.....	75	7	68	38	24	54	26	56	53	85	3.20	.....	8	7,073	se.	28	n.	22	14	7	10	4.4	0.0	0.0
San Antonio	701	119	132	29.34	30.08	−.02	62.0	+10.9	86	7	73	38	23	51	36	53	45	62	0.46	−1.2	6	6,150	s.	32	n.	21	15	6	10	4.2	0.0	0.0
Taylor	582	55	63	29.48	30.10	−.01	59.0	+11.5	84	8	70	34	3	47	40	.....	.....	.....	0.37	−2.4	4	7,350	s.	33	s.	20	11	9	11	5.0	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, January, 1923*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.* 39.2	° *F.* +5.9	° *F*		° *F*	° *F.*		° *F*	° *F.*		° *F.*	° *F.*	% 76	*In.* 4.75	*In.* +0.9		*Miles.*								0–10 7.6	*In.*	*In.*
Chattanooga	762	189	213	29.33	30.16	.00	46.6	+5.4	65	21	55	28	4	38	30		41	35	67	4.81	−0.8	15	6,621	se.	35	nw.	16	8	11	12	6.1	0.0	0.0
Knoxville	996	102	111	29.14	30.14	−.01	44.0	+5.2	63	11	52	25	17	36	34		40	34	73	5.73	+0.8	14	5,444	sw.	40	sw.	18	3	8	20	7.6	0.0	0.0
Memphis	399	76	97	29.68	30.11	−.05	49.2	+8.3	66	21	57	31	3	42	26		44	38	69	5.05	−0.2	11	7,196	s.	37	sw.	11	9	7	15	6.3	0.0	0.0
Nashville	546	168	191	29.55	30.14	−.02	45.0	+6.4	68	11	54	27	4	36	35		40	34	70	5.89	+1.0	14	8,675	s.	38	nw.	9	6	6	19	7.0	T.	0.0
Lexington	989	193	230	29.03	30.12	−.01	39.1	+6.1	59	11	47	17	17	31	28		.....	.....	.....	6.63	+2.8	13	12,119	sw.	55	sw.	18	6	6	19	7.2	T.	0.0
Louisville	525	219	255	29.53	30.13	−.01	40.4	+6.0	59	11	48	20	17	33	27		35	30	71	5.65	+1.8	12	9,977	w.	42	s.	14	6	7	18	7.3	T.	0.0
Evansville	431	139	175	29.63	30.12	−.02	40.8	+8.5	63	18	48	25	17	34	24		36	32	74	5.43	+1.7	11	9,389	nw.	42	sw.	18	3	10	18	7.2	T.	0.0
Indianapolis	822	194	230	29.18	30.09	−.03	34.6	+6.2	56	18	41	19	17	28	27		31	28	80	2.73	−0.1	16	10,407	w.	42	w.	15	4	5	22	8.0	0.6	0.0
Royal Center	736	11	55	29.24	30.07	.....	29.6	.....	48	18	36	6	10	23	28		.....	.....	.....	1.92	.....	15	9,144	w.	35	s.	17	5	6	20	7.6	11.5	0.0
Terre Haute	575	96	129	29.45	30.08	.....	36.2	.....	58	18	43	22	17	29	28		33	30	83	1.86	.....	9	8,080	nw.	39	nw.	14	4	7	20	7.5	0.1	0.0
Cincinnati	628	11	51	29.40	30.10	−.02	36.5	+6.2	58	18	44	15	17	29	32		.....	31	80	4.64	+1.3	13	7,047	w.	34	sw.	18	7	4	20	7.5	T.	0.0
Columbus	824	179	222	29.19	30.09	−.02	33.8	+5.2	54	18	40	11	17	27	25		30	27	77	3.46	+0.5	15	9,695	nw.	36	s.	18	3	7	21	8.0	0.9	0.0
Dayton	899	181	216	29.10	30.09	.....	34.5	+5.6	56	18	41	13	17	28	28		31	28	80	3.83	+0.8	17	9,213	nw.	39	nw.	15	4	9	18	7.5	0.2	0.0
Elkins	1,947	59	67	27.98	30.11	−.01	34.0	+5.0	59	21	43	6	11	25	42		31	27	79	5.06	+1.7	24	5,386	w.	32	w.	11	1	6	24	8.6	7.1	0.0
Parkersburg	638	77	84	29.44	30.12	.00	37.0	+5.7	60	18	45	12	17	29	33		33	29	75	4.14	+1.0	15	5,366	sw.	32	nw.	14	3	4	24	8.3	0.2	0.0
Pittsburgh	842	353	410	29.15	30.08	−.03	33.4	+2.7	55	18	40	11	17	27	32		31	27	79	3.49	+0.6	15	9,625	w.	43	nw.	16	1	3	27	9.1	2.9	0.0
Lower Lake Region.							25.3	+0.8											80	2.72	+0.1									8.4		
Buffalo	767	247	280	29.19	30.05	−.02	25.4	+0.8	44	18	32	−2	17	19	27		23	20	83	3.27	0.0	20	13,147	w.	60	sw.	18	3	3	25	8.4	22.6	5.0
Canton	448	10	61	29.56	30.07	.....	10.8	−5.5	44	20	20	−20	30	1	42		.....	.....	.....	2.86	−0.3	17	7,899	e.	47	w.	19	9	4	18	6.5	21.4	6.6
Oswego	335	76	91	.....	30.07	.00	20.3	−3.6	41	21	28	−5	17	13	35		.....	.....	.....	2.22	−0.9	23	9,264	s.	33	s.	18	2	3	26	....	31.8	12.3
Rochester	523	86	102	29.48	30.08	+.01	24.0	−0.6	47	18	31	0	17	17	32		22	18	77	3.55	+0.4	21	6,910	w.	37	w.	18	2	3	26	8.8	38.5	15.0
Syracuse	597	97	113	29.40	30.08	+.01	21.2	−1.8	46	21	29	−5	17	14	33		.....	.....	.....	3.78	+1.6	22	8,377	nw.	51	s.	18	2	3	26	8.7	36.0	9.0
Erie	714	130	166	29.25	30.05	−.03	28.7	+1.9	49	18	35	7	17	23	25		27	23	78	2.67	−0.4	15	12,339	nw.	53	se.	18	1	3	27	9.2	17.5	2.0
Cleveland	762	190	201	29.22	30.07	−.02	30.2	+3.7	52	18	36	11	17	25	25		28	24	79	2.61	+0.2	16	11,715	w.	44	s.	17	1	4	26	9.1	6.9	0.0
Sandusky	629	62	103	29.36	30.06	−.03	30.5	+4.2	53	18	36	6	17	25	25		.....	.....	.....	2.50	+0.4	13	7,188	w.	35	nw.	16	1	8	22	8.6	8.0	0.0
Toledo	628	208	243	29.37	30.08	−.01	29.7	+3.9	51	18	36	3	17	24	26		28	24	79	1.75	−0.2	12	10,652	w.	43	nw.	18	4	3	24	8.3	9.5	0.0
Fort Wayne	856	113	124	29.12	30.08	.....	30.1	+3.2	50	18	36	11	17	25	27		28	24	80	1.99	.....	15	7,900	w.	38	sw.	18	2	8	21	8.0	12.0	0.0
Detroit	730	218	258	29.25	30.07	−.01	27.0	+2.6	45	18	33	1	17	21	27		26	22	81	1.94	0.0	17	8,979	nw.	40	sw.	18	2	7	22	8.1	15.6	0.3
Upper Lake Region.							21.0	+2.7											84	1.66	−0.4									8.0		
Alpena	609	13	92	29.38	30.07	+.03	19.2	+0.1	43	18	27	−6	30	11	32		18	16	86	1.72	−0.5	17	9,491	nw.	50	nw.	18	1	14	16	7.8	19.9	7.0
Escanaba	612	54	60	29.38	30.08	+.03	17.8	+3.3	42	18	25	−7	23	11	34		17	14	86	1.98	+0.4	14	6,779	nw.	40	nw.	18	5	7	19	7.4	23.2	8.0
Grand Haven	632	54	89	29.34	30.05	−.02	25.8	+1.5	42	18	31	6	17	20	32		25	23	88	1.57	−1.2	15	9,597	e.	43	w.	12	1	2	28	9.0	11.0	0.4
Grand Rapids	707	70	87	29.27	30.06	.00	26.2	+2.4	44	20	32	3	17	21	33		24	21	78	1.25	−1.5	14	5,503	w.	30	w.	18	1	7	23	8.4	13.1	0.8
Houghton	684	62	99	29.29	30.05	.00	16.6	+2.1	39	18	24	−10	20	9	38		.....	.....	.....	2.07	0.0	17	6,913	e.	58	w.	18	1	4	26	9.2	22.2	17.0
Lansing	878	11	62	29.07	30.05	.....	23.6	+1.6	43	18	31	−5	17	16	36		23	21	86	1.65	−0.4	20	5,330	nw.	27	nw.	14	1	8	22	8.4	16.3	3.0
Ludington	637	60	66	29.33	30.05	.....	24.1	.....	41	18	30	3	6	18	32		23	20	85	1.95	.....	19	8,266	se.	39	w.	18	3	6	22	8.1	21.3	3.0
Marquette	734	77	111	29.26	30.10	+.06	19.2	+3.3	41	18	25	4	20	13	31		17	15	87	2.84	+0.8	21	7,485	w.	42	w.	18	1	9	21	8.4	28.3	14.2
Port Huron	638	70	120	29.33	30.05	−.01	24.1	+1.8	43	18	30	1	17	18	25		23	21	85	1.54	−0.4	14	9,249	nw.	43	nw.	18	1	8	22	8.3	19.8	4.8
Saginaw	641	69	77	29.34	30.06	.....	22.4	.....	42	18	29	−5	17	16	35		22	19	84	0.91	−1.4	16	6,635	nw.	29	sw.	18	0	6	25	8.9	10.6	2.5
Sault Sainte Marie	614	11	52	29.37	30.11	+.08	11.2	−2.1	37	18	20	−19	17	3	38		10	8	87	1.64	−0.5	18	5,916	e.	51	nw.	18	3	8	20	7.8	18.0	15.3
Chicago	823	140	310	29.14	30.06	−.04	30.8	+5.7	49	18	37	11	10	25	23		28	23	70	0.92	−1.1	15	9,140	w.	42	s.	17	5	9	17	7.2	4.4	0.0
Green Bay	617	109	144	29.36	30.05	−.01	19.4	+4.8	42	18	26	−2	17	12	37		18	15	82	1.73	0.0	12	7,765	w.	48	w.	18	4	7	20	7.8	20.1	4.0
Milwaukee	681	125	139	29.29	30.05	−.03	25.8	+5.2	44	18	32	8	10	20	29		24	20	76	1.78	−0.2	15	8,258	w.	40	e.	27	4	6	21	7.6	18.6	0.5
Duluth	1,133	11	47	28.78	30.07	−.02	13.0	+5.1	39	18	21	−17	19	5	49		12	11	93	1.60	+0.6	12	9,655	nw.	70	nw.	18	11	6	14	6.0	22.2	16.0
North Dakota.							10.4	+5.9											87	0.44	−0.2									6.8		
Moorhead	940	50	58	29.00	30.08	−.06	11.0	+7.2	41	17	20	−19	5	2	38		9	7	88	0.47	−0.2	13	6,102	nw.	40	nw.	18	8	5	18	7.0	6.0	4.9
Bismarck	1,674	8	57	28.20	30.09	−.04	12.3	+4.5	44	17	24	−20	31	1	37		11	9	88	0.29	−0.2	6	5,883	nw.	39	nw.	8	5	7	19	7.1	4.1	6.5
Devils Lake	1,482	11	44	28.39	30.06	−.06	6.0	+5.7	41	17	16	−21	5	−4	30		5	3	87	0.42	−0.2	7	7,003	se.	50	nw.	17	9	10	12	6.0	6.5	6.1
Ellendale	1,457	10	56	28.44	30.07	.....	13.5	.....	43	17	23	−11	5	4	38		.....	.....	.....	0.59	.....	9	10,187	nw.	54	nw.	8	5	9	17	7.3	7.8	4.0
Grand Forks	835	12	89	.....	.....	.....	6.7	.....	47	17	18	−26	5	−4	55		.....	.....	.....	0.28	.....	7	.....	n.	50	nw.	18	16	5	10	....	2.8	6.7
Williston	1,878	41	48	27.94	30.00	−.11	12.5	+6.1	49	17	23	−18	31	2	41		12	9	84	0.56	0.0	9	5,354	se.	34	nw.	17	7	6	18	6.9	7.4	3.6
Upper Mississippi Valley.							29.0	+7.8											79	1.47	−0.2									7.1		
Minneapolis	918	102	208	29.02	30.05	.....	18.0	.....	44	18	26	−5	5	10	41		.....	.....	.....	1.01	+0.3	12	8,484	se.	46	n.	18	3	10	18	7.5	11.8	6.2
St. Paul	837	236	261	29.11	30.06	−.05	17.6	+5.0	43	18	26	−3	5	10	41		.....	.....	.....	1.12	+0.2	13	8,709	se.	45	nw.	18	2	12	17	7.3	12.9	6.5
La Crosse	714	11	48	29.25	30.05	−.06	21.6	+5.5	43	18	30	4	21	14	34		.....	.....	.....	0.75	−0.3	10	3,683	se.	24	s.	17	4	5	22	7.7	9.4	2.5
Madison	974	70	78	28.98	30.08	−.02	22.0	+5.3	42	18	29	2	29	15	33		21	19	88	1.25	−0.3	11	7,147	nw.	31	nw.	18	5	7	19	7.4	11.0	2.9
Wausau	1,247	4	.....	28.66	30.06	.....	16.8	.....	40	18	24	−8	25	9	39		.....	.....	.....	1.29	.....	13	.....	se.	.....	.....	.....	8	3	20	7.5	14.2	3.4
Charles City	1,015	10	49	28.94	30.07	−.07	21.9	+10.5	42	17	30	−3	6	14	34		20	18	88	0.89	−0.1	11	5,317	se.	26	se.	11	8	4	19	7.0	7.5	1.0
Davenport	606	71	79	29.38	30.07	−.05	29.2	+7.4	50	18	36	14	12	22	30		26	24	80	0.97	−0.6	12	5,952	e.	26	nw.	18	5	8	18	7.2	8.0	T.
Des Moines	861	84	97	29.11	30.05	−.09	29.3	+9.2	55	18	37	2	6	22	31		27	23	76	0.88	−0.3	10	5,375	nw.	26	sw.	17	7	5	19	6.8	7.8	T.
Dubuque	698	81	93	29.30	30.09	−.03	25.8	+6.7	46	18	33	11	12	19	32		24	20	79	0.63	−0.9	10	5,149	nw.	28	nw.	18	8	6	17	6.7	4.5	0.5
Keokuk	614	64	78	29.38	30.08	−.06	33.9	+9.0	56	18	41	12	6	26	27		30	25	74	1.13	−0.6	7	6,144	nw.	30	nw.	14	5	7	19	7.0	7.3	0.0
Cairo	358	87	93	29.71	30.10	−.06	43.4	+8.5	65	18	51	28	1	36	26		38	32	70	7.01	+3.2	9	7,706	s.	35	sw.	18	5	5	21	7.4	0.0	0.0
Peoria	609	11	45	29.39	30.08	−.04	31.8	+8.7	50	18	38	15	22	25	24		29	26	83	1.10	−1.1	11	5,817	se.	27	nw.	9	6	9	16	7.0	5.4	0.0
Springfield, Ill.	644	10	91	29.36	30.06	−.07	34.6	+8.1	54	18	40	20	22	29	24		31	28	79	1.06	−1.2	9	7,277	w.	29	s.	17	5	8	18	7.3	3.8	0.0
Hannibal	534	74	109	29.47	30.06	−.07	36.5	+9.4	58	18	44	16	6	29	26		.....	.....	.....	0.75	−1.4	8	6,795	nw.	30	s.	17	6	9	16	6.5	2.4	0.0
St. Louis	567	265	303	29.45	30.07	−.07	39.5	+8.7	62	18	46	24	6	33	25		36	30	71	2.08	−0.2	8	10,710	s.	44	s.	17	5	11	15	6.7	0.0	0.0
Missouri Valley.							33.0	+11.1											71	0.79	−0.2									5.9		
Columbia, Mo.	781	11	84	29.20	30.06	−.07	38.9	+11.7	60	17	48	20	6	30	32		.....	.....	.....	1.40	−0.8	5	7,027	w.	28	nw.	9	9	5	17	6.5	T.	0.0
Kansas City	963	161	181	29.00	30.06	−.09	39.0	+12.8	63	17	48	19	6	30	30		33	27	66	0.16	−1.0	3	8,656	nw.	43	nw.	7	12	9	10	5.3	T.	0.0
St. Joseph	967	11	49	28.98	30.05	.....	36.6	.....	62	17	45	18	5	28	30		31	26	70	0.26	.....	5	6,618	nw.	36	nw.	7	10	10	11	5.5	0.6	0.0
Springfield, Mo.	1,324	98	104	28.64	30.07	−.07	42.7	+11.4	64	8	51	21	3	34	30		37	31	71	3.43	+0.8	6	8,353	se.	40	w.	8	14	4	13	5.3	0.0	0.0
Iola	984	11	50	28.99	30.06	−.08	40.6	+13.0	68	8	52	18	3	29	38		.....	.....	.....	1.16	+0.2	5	5,374	s.	33	nw.	7	6	11	14	6.4	0.0	0.0
Topeka	987	92	107	.....	.....	.....	38.6	+13.0	68	13	49	18	3	28	33		.....	.....	.....	0.07	−0.9	3	7,817	nw.	40	nw.	7	13	6	12	5.3	0.0	0.0
Drexel	1,299	10	54	28.61	30.03	.....	29.6	.....	53	18	39	7	2	20	33		.....	.....	.....	0.90	.....	5	7,665	nw.	30	sw.	17	6	9	16	6.9	7.7	T.
Lincoln	1,189	11	84	28.75	30.06	−.09	33.6	+12.4	58	18	43	14	3	24	32		28	22	70	0.14	−0.5	4	7,483	n.	42	nw.	8	6	12	13	6.2	1.2	T.
Omaha	1,105	115	122	28.84	30.05	−.09	32.5	+10.6	56	17	40	12	6	24	32		28	22	71	0.87	+0 2	5	6,199	nw.	28	nw.	18	9	7	15	6.0	7.6	0.2
Valentine	2,598	47	54	27.24	30.04	−.08	28.6	+9.7	63	17	39	−1	30	18	38		24	18	68	0.49	0.0	6	6,990	w.	43	w.	17	8	15	8	4.9	7.1	0.0
Sioux City	1,135	94	164	28.80	30.06	−.09	27.7	+9.9	57	18	36	6	28	20	34		24	19	73	0.81	+0.3	6	9,128	nw.	44	nw.	13	9	7	15	6.3	7.9	0.6
Huron	1,306	59	74	28.63	30.09	−.07	21.4	+10.1	58	17	31	−11	28	11	41		18	14	78	0.28	−0.2	7	7,110	nw.	36	se.	23	12	7	12	5.5	6.3	1.8
Pierre	1,572	70	75	28.33	30.06	−.07	24.9	+8.9	57	17	33	−1	30	16	32		22	17	75	0.14	−0.3	5	5,930	nw.	33	nw.	17	8	9	14	6.1	1.3	0.0
Yankton	1,233	49	57	28.69	30.06	−.10	27.2	+9.8	63	17	36	0	28	18	41		.....	.....	.....	0.48	−0.1	5	6,081	nw.	33	nw.	18	6	11	14	6.4	5.7	1.3

TABLE I.—*Climatological data for Weather Bureau stations, January, 1923*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F*	° *F.*		° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
Northern Slope.							**27.0**	**+7.8**											**67**	**0.61**	**−0.3**									**5.8**		
Billings	3,140	5					30.6		60	10	42	−14	30	19	38					0.11		3		nw.				17	7	7		1.5	
Havre	2,505	11	44	27.25	29.98	−.12	19.4	+6.5	49	10	29	−22	30	10	36	17	15	85		1.12	+0.4	10	5,357	sw.	40	sw.	17	10	5	16	6.1	8.9	2.9
Helena	4,110	87	112	25.69	29.99	−.16	27.8	+7.6	56	10	36	−12	29	20	28	24	18	66		0.44	−0.5	7	6,655	sw.	50	sw.	6	5	9	17	7.2	1.9	1.3
Kalispell	2,973	48	56	26.83	29.96	−.16	27.4	+7.8	48	10	33	−10	30	21	22	26	22	77		1.07	−0.5	16	3,801	nw.	34	sw.	17	1	10	20	7.9	3.6	2.6
Miles City	2,371	48	55	27.41	30.04	−.08	25.5	+11.0	59	17	35	−15	30	16	30	22	17	72		0.41	−0.2	7	3,586	s.	36	w.	17	6	11	14	5.8	3.2	1.2
Rapid City	3,259	50	58	26.52	30.04	−.06	29.6	+8.1	62	17	41	0	30	18	41	25	17	59		0.37	−0.1	5	6,481	w.	42	n.	17	8	13	10	5.6	3.9	0.1
Cheyenne	6,088	84	101	23.91	30.01	−.04	32.2	+6.7	57	17	42	7	31	23	42	25	14	49		0.06	−0.3	2	14,377	w.	82	w.	3	16	11	4	3.6	0.7	T.
Lander	5,372	60	68	24.56	30.05	−.07	27.0	+9.6	55	10	37	−4	31	17	34	22	16	65		0.41	0.0	4	4,186	w.	64	sw.	7	10	16	5	4.7	3.9	2.4
Sheridan	3,790	10	47	26.01	30.01	.....	28.4	.....	64	17	49	−11	31	17	33	23	16	62		0.57	.....	7	4,411	nw.	40	nw.	18	8	14	9	5.9	6.1	4.5
Yellowstone Park	6,206	11	48	23.77	30.08	−.06	20.8	+3.2	40	6	28	−12	30	13	33	19	14	73		1.49	−0.8	19	7,077	s.	42	s.	17	0	15	16	7.5	17.0	21.0
North Platte	2,821	11	51	27.07	30.08	−.04	32.9	+10.0	65	17	46	5	30	26	45	25	17	61		0.11	−0.4	3	5,203	w.	32	nw.	8	16	7	8	4.0	1.2	0.0
Middle Slope.							**40.4**	**+10.9**											**54**	**0.49**	**−0.2**									**4.6**		
Denver	5,292	106	113	24.65	29.98	−.07	37.9	+8.1	67	10	49	17	30	27	40	30	17	46		0.13	−0.3	2	5,960	s.	47	sw.	7	18	9	4	3.2	1.3	T.
Pueblo	4,685	80	86	25.23	29.98	−.07	39.0	+9.9	70	17	54	8	28	24	50	29	14	40		T.	−0.4	0	6,009	nw.	46	nw.	8	19	10	2	3.5	T.	0.0
Concordia	1,392	50	58	28.54	30.05	−.09	37.2	+12.8	65	17	48	14	22	26	34	30	21	61		0.01	−0.7	1	6,052	nw.	38	nw.	7	7	11	13	6.4	T.	0.0
Dodge City	2,509	11	51	27.42	30.09	−.03	39.0	+10.0	73	17	54	15	28	24	42	29	21	58		0.03	−0.4	1	6,795	nw.	38	nw.	8	15	13	3	3.8	0.1	0.0
Wichita	1,358	139	158	28.58	30.04	−.09	41.4	+11.7	68	13	52	18	6	31	28	35	27	60		0.02	−0.8	2	9,469	s.	51	s.	17	12	10	9	5.1	T.	0.0
Broken Arrow	765	11	52	29.23	30.07	.....	46.6	.....	72	8	58	24	6	35	35	.....	.....	.....		4.08	.....	8	9,755	s.	46	s.	1	13	5	13	5.6	0.5	0.0
Muskogee	652	4	.....	.....	.....	.....	48.4	.....	76	11	60	24	3	37	39	.....	.....	.....		6.23	.....	8	.....	n.	.....	.....	.....	13	9	9	.....	T.	0.0
Oklahoma City	1,214	10	47	28.77	30.07	−.04	47.8	+13.1	72	13	59	24	6	37	33	39	30	56		2.74	+1.4	3	8,755	s.	36	n.	7	16	3	12	4.7	0.0	0.0
Southern Slope.							**51.2**	**+9.7**											**48**	**1.10**	**+0.4**									**3.9**		
Abilene	1,738	10	52	28.24	30.06	−.03	53.4	+10.8	78	8	65	27	3	42	39	43	31	52		3.10	+2.2	8	7,406	sw.	39	sw.	17	14	5	12	5.1	T.	0.0
Amarillo	3,676	10	49	26.27	30.04	−.02	46.2	+12.3	73	17	60	20	3	32	41	36	26	52		0.00	−0.6	0	7,964	sw.	38	sw.	17	20	11	0	2.9	0.0	0.0
Del Rio	944	64	71	29.07	30.07	+.01	58.5	+8.3	83	7	71	30	4	46	44	.....	.....	.....		0.84	0.0	5	5,445	se.	34	n.	27	20	2	9	3.8	0.0	0.0
Roswell	3,566	75	85	26.40	30.04	.00	46.5	+7.3	76	17	61	17	3	32	49	35	19	40		0.44	0.0	2	5,376	s.	46	nw.	8	15	12	4	3.9	0.0	0.0
Southern Plateau.							**45.4**	**+4.6**											**49**	**0.23**	**−0.5**									**3.1**		
El Paso	3,762	110	133	26.24	30.05	+.04	49.1	+5.0	69	19	61	22	4	38	37	38	24	41		0.64	+0.1	4	6,753	nw.	29	n.	1	16	12	3	3.5	0.0	0.0
Santa Fe	7,013	38	53	23.24	30.10	+.06	34.9	+6.1	56	11	45	13	2	25	28	27	18	56		0.12	−0.5	3	4,805	n.	29	n.	6	15	13	3	3.6	1.3	0.0
Flagstaff	6,908	10	59	23.34	30.03	−.02	33.2	+6.5	63	10	47	−2	28	20	44	25	....	58		2.39	.....	9	5,760	w.	30	w.	6	20	6	5	....	18.7	7.0
Phoenix	1,108	11	81	28.84	30.01	−.02	55.4	+5.4	84	9	70	29	2	41	44	44	34	53		0.28	−0.9	3	3,098	e.	26	e.	22	21	4	6	2.7	0.0	0.0
Yuma	141	9	54	29.87	30.02	−.03	58.2	+3.8	81	18	71	34	4	45	37	45	30	39		T.	−0.4	0	2,537	n.	18	nw.	31	20	8	3	2.8	0.0	0.0
Independence	3,957	9	41	26.00	30.09	+.02	41.5	+1.0	72	17	55	16	31	28	38	31	19	45		0.09	−0.8	1	4,205	nw.	31	sw.	17	22	5	4	2.9	T.	0.0
Middle Plateau.							**33.3**	**+4.8**											**65**	**1.26**	**+0.2**									**5.7**		
Reno	4,532	74	81	25.49	30.12	−.01	33.2	+0.7	62	7	44	−8	31	22	38	28	21	66		1.90	0.0	8	3,985	w.	46	w.	17	6	12	13	6.5	22.9	11.0
Tonopah	6,090	12	20	24.04	30.10	.....	33.8	.....	58	7	41	5	31	27	26	27	19	61		0.76	0.0	5	5,283	se.	42	se.	22	14	10	7	4.4	12.5	10.5
Winnemucca	4,344	18	56	25.64	30.13	−.03	30.4	+1.8	57	7	41	−10	31	20	31	27	22	72		0.91	−0.1	11	5,758	sw.	42	s.	17	4	7	20	7.8	11.3	6.5
Modena	5,479	10	43	24.61	30.06	−.04	33.5	+6.0	63	7	46	2	27	20	43	26	18	58		1.40	+0.7	9	7,805	w.	46	sw.	28	16	7	8	4.2	12.1	5.9
Salt Lake City	4,360	163	203	25.65	30.10	−.05	36.0	+6.8	57	7	43	21	27	29	21	31	24	65		1.90	+0.6	12	4,675	nw.	30	s.	28	8	7	16	6.7	17.0	9.2
Grand Junction	4,602	60	68	25.42	30.08	+.02	33.5	+8.8	53	13	45	3	28	22	35	28	22	68		0.70	+0.2	4	3,681	se.	35	s.	29	12	12	7	4.6	5.6	0.0
Northern Plateau.							**35.2**	**+6.2**											**73**	**1.50**	**−0.1**									**7.7**		
Baker	3,471	48	53	26.43	30.09	−.07	30.0	+6.1	49	6	37	3	31	23	24	28	24	77		0.80	−0.5	12	4,659	se.	30	sw.	10	4	8	19	7.1	3.9	0.5
Boise	2,739	78	86	27.21	30.13	−.06	35.5	+5.7	59	9	43	10	31	28	28	32	26	66		1.62	−0.3	11	4,198	se.	28	se.	17	2	7	22	7.9	8.1	1.2
Lewiston	757	40	48	29.19	30.02	−.14	39.9	+5.4	61	7	46	19	31	34	19	.....	.....	.....		1.66	+0.1	14	3,241	e.	36	w.	17	2	12	17	7.7	0.3	0.0
Pocatello	4,477	60	68	25.47	30.10	−.10	31.5	+6.4	53	10	38	1	31	25	26	27	22	68		1.14	+0.5	12	8,824	sw.	40	sw.	6	4	7	20	7.6	8.5	4.5
Spokane	1,929	101	110	27.91	30.01	−.11	33.2	+5.7	52	6	38	2	30	28	22	32	29	81		1.90	−0.4	17	5,772	sw.	34	sw.	10	3	7	21	7.7	5.4	3.4
Walla Walla	991	57	65	28.94	30.03	−.12	40.8	+7.6	63	16	46	15	30	36	30	37	32	72		1.85	−0.2	12	5,022	s.	38	w.	7	1	8	22	8.4	1.6	0.0
North Pacific Coast Region.							**41.8**	**+1.6**											**86**	**9.07**	**+2.3**									**8.1**		
North Head	211	11	56	29.74	29.97	−.08	42.8	+1.0	53	16	46	28	30	39	14	41	40	87		10.07	+3.4	22	15,180	s.	84	s.	17	4	4	23	8.1	1.8	0.0
Port Angeles	29	8	53	29.94	29.97	.....	39.2	.....	55	16	44	19	29	34	17	.....	.....	.....		5.45	0.0	20	4,765	s.	32	sw.	7	1	7	23	8.5	2.2	0.8
Seattle	125	215	250	29.86	30.00	−.05	40.4	+1.1	53	6	44	23	30	36	13	39	36	84		7.51	+2.7	18	9,828	s.	53	sw.	7	1	9	21	8.1	1.0	T.
Tacoma	213	113	120	29.77	30.00	−.04	40.2	+2.1	53	6	44	20	30	36	16	.....	.....	.....		10.90	+5.1	20	6,563	sw.	36	sw.	7	1	10	20	8.0	5.0	0.5
Tatoosh Island	86	9	57	29.82	29.92	−.06	42.0	+0.8	52	16	45	31	30	39	11	40	38	87		14.30	+2.1	24	14,020	e.	60	s.	16	3	6	22	7.9	T.	0.0
Yakima	1,071	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Medford	1,425	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portland, Oreg	153	68	106	29.87	30.03	−.05	42.8	+3.4	56	7	47	26	30	39	14	42	40	88		9.57	+3.1	23	5,818	sw.	31	sw.	7	2	2	27	8.8	1.9	T.
Roseburg	510	9	57	29.54	30.10	.00	42.6	+1.4	63	16	48	23	30	37	26	41	38	84		5.69	0.0	24	1,978	s.	18	sw.	10	1	13	17	7.6	4.5	1.0
Middle Pacific Coast Region.							**46.0**	**−1.6**											**82**	**2.50**	**−2.0**									**6.5**		
Eureka	62	73	89	30.08	30.15	+.05	46.9	0.0	67	15	53	27	31	41	28	44	41	80		3.88	−3.8	24	4,561	se.	42	s.	16	2	11	18	7.6	0.0	0.0
Point Reyes	490	7	18	29.57	30.09	.....	48.4	−1.0	64	9	52	34	30	44	16	.....	.....	.....		1.92	.....	12	13,948	nw.	66	s.	16	9	13	9	5.4	0.0	0.0
Red Bluff	332	50	56	29.78	30.15	+.03	43.1	−2.7	63	20	50	29	26	36	28	41	37	80		1.80	−2.1	9	3,399	nw.	31	se.	27	9	8	14	6.2	0.0	0.0
Sacramento	69	106	117	30.08	30.16	+.04	43.8	−2.0	59	17	49	31	13	39	19	42	40	87		2.05	−1.6	9	4,357	se.	32	se.	22	4	11	16	7.3	0.0	0.0
San Francisco	155	208	243	29.96	30.13	+.02	48.1	−1.8	58	17	53	36	30	43	17	45	42	81		2.84	−1.5	11	4,732	n.	26	nw.	28	10	7	14	6.0	0.0	0.0
San Jose	141	12	110	29.99	30.15	.....	46.0	−2.3	64	5	55	28	31	37	28	.....	.....	.....		1.93	−1.0	10	3,395	nw.	30	se.	22	6	14	11	6.3	T.	0.0
South Pacific Coast Region.							**53.5**	**+2.2**											**69**	**2.18**	**−0.6**									**5.0**		
Fresno	327	89	98	29.79	30.16	+.06	46.2	+0.8	67	16	53	31	27	40	31	44	40	81		1.10	−0.5	7	3,386	nw.	24	se.	22	6	7	18	7.2	0.0	0.0
Los Angeles	338	159	191	29.69	30.06	−.02	58.1	+3.5	90	8	67	39	31	49	28	49	40	61		1.76	−1.1	7	3,984	e.	22	sw.	31	17	3	11	4.4	0.0	0.0
San Diego	87	62	70	29.94	30.04	−.03	56.3	+2.0	85	9	64	40	4	48	26	50	45	73		1.34	−0.7	6	3,684	nw.	25	s.	29	15	7	9	4.7	0.0	0.0
San Luis Obispo	201	32	40	29.89	30.11	+.02	53.3	+2.3	84	9	63	34	30	44	37	45	38	62		4.51	−0.2	7	4,011	n.	29	ne.	6	17	10	4	3.8	0.3	0.0
West Indies.																																		
San Juan, P. R	82	9	54	29.96	30.05	.....	73.6	−1.4	80	11	78	66	26	69	12	.....	.....	.....		2.84	−1.8	24	11,910	e.	39	e.	14	7	13	11	5.8	0.0	0.0
Panama Canal.																																		
Balboa Heights	118	7	97	29.73	29.85	−.01	79.0	−1.0	89	4	87	70	8	71	18	71	70	78		0.80	−0.2	4	6,840	nw.	32	n.	30	5	24	2	4.8	0.0	0.0
Colon	36	7	97	29.83	29.86	−.01	80.4	+0.4	87	13	85	72	7	76	13	74	72	76		1.98	−1.7	12	13,298	n.	36	ne.	19	4	22	5	5.3	0.0	0.0
Alaska.																																		
Juneau	80	11	54	.....	.....	.....	26.5	.....	38	8	30	12	28	23	15	24	19	73		5.16	.....	21	5,858	s.	38	e.	17	7	1	23	7.9	46.2	19.0

TABLE II.—*Data furnished by the Canadian Meteorological Service, January, 1923.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
St. Johns, N. F.	125												
Sydney, C. B. I.	48	29.84	29.89	−0.04	19.1	−1.4	27.0	11.2	44	−8	6.53	+1.43	36.5
Halifax, N. S.	88	29.81	29.92	−.05	20.2	−1.6	28.4	12.0	45	−8	5.16	−0.61	26.1
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38	29.86	29.90	−.06	14.6	−2.4	22.7	6.4	44	−21	4.57	+0.61	43.5
Chatham, N. B.	28	29.86	29.90	−.07	8.9	−0.9	19.7	−2.0	45	−35	4.10	+0.51	34.0
Father Point, Que.	20												
Quebec, Ont.	296	29.74	30.08	+.06	7.3	−1.8	14.4	0.1	40	−14	4.21	+0.20	33.4
Montreal, Que.	187	29.86	30.09	+.05	11.5	−0.2	18.9	4.1	40	−10	3.25	−0.48	22.5
Stornecliffe, Ont.	489												
Ottawa, Ont.	236	29.83	30.12	+.09	8.3	−1.3	16.6	0.0	40	−17	3.15	+0.16	30.7
Kingston, Ont.	285	29.74	30.08	+.03	13.5	−3.6	20.2	6.7	40	−12	1.71	−1.74	12.1
Toronto, Ont.	379	29.64	30.07	+.02	21.8	+0.4	29.8	13.9	43	−12	3.17	+0.25	28.5
Cochrane, Ont.	930												
White River, Ont.	1,244	28.66	30.06	+.05	−1.8	−1.4	13.2	−16.8	32	−44	1.02	−0.67	10.2
Port Stanley, Ont.	592												
Southampton, Ont.	656	29.30			18.1	−2.3	25.8	10.3	40	−14	2.37	−1.68	22.7
Parry Sound, Ont.	688	29.34	30.08	+.07	10.3	−3.5	19.7	0.9	39	−24	2.46	−1.62	24.6
Port Arthur, Ont.	644	29.34	30.08	+.01	8.3	+5.2	16.7	−0.6	37	−24	0.84	+0.02	8.4
Winnipeg, Man.	760	29.19	30.09	−.02	2.0	+8.8	11.6	−7.6	42	35	1.65	+0.77	16.5
Minnedosa, Man.	1,690	28.11	30.05	−.05	−0.7	+6.5	8.0	−9.4	39	−37	0.69	−0.11	6.9
Le Pas, Man.	860				−4.8		6.0	−15.6	25	−36	0.77		7.7
Qu'Appelle, Sask.	2,115	27.59	29.96	−.12	4.1	+7.9	13.8	−5.6	44	−28	1.40	+0.90	14.0
Medicine Hat, Alb.	2,144	27.52	29.86	−.21	18.4	+12.9	28.5	8.3	48	−26	0.70	+0.13	7.0
Moose Jaw, Sask.	1,759				8.0		17.0	− 1.0	44	−19	0.43		4.3
Swift Current, Sask.	2,392	27.26	30.01	−.08	11.6	+8.5	21.4	1.8	49	−22	0.40	−0.24	4.0
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Edmonton, Alb.	2,150												
Prince Albert, Sask.	1,450	28.36	30.04	−.05	−0.4	+8.0	11.3	−12.1	28	−39	0.45	−0.52	4.5
Battleford, Sask.	1,592	28.13	29.97	−.11	2.6	+8.5	13.2	−8.0	40	−25	0.55	+0.15	5.5
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.69	29.95	−.02	39.7	+1.2	43.0	36.4	53	24	6.41	+1.02	1.4
Barkerville, B. C.	4,180												
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	30.00	30.17	+.04	61.2	−0.8	67.3	55.2	73	43	4.40	−0.54	0.0
St. Johns, N. F.[1]	125	29.65	29.79	−.04	21.5	−7.2	26.7	16.3	44	2	4.42	−0.61	30.0
Calgary, Alb.[1]	3,428	26.30	30.07	+.13	10.7	−7.5	23.6	−2.2	54	−30	0.29	−0.30	2.9
Kamloops, B. C.[1]	1,262	28.78	30.14	+.20	17.7	−11.2	21.7	13.7	46	−17	1.18	+0.40	9.7
Barkerville, B. C.[1]	4,180	25.46	29.92	+.04	11.5	−9.4	17.5	5.6	37	−23	3.75	+0.58	37.5
Hamilton, Ber.[1]	151	30.06	30.22	−.13	65.3	+0.6	71.1	59.6	76	54	3.16	−1.33	0.0

[1] Late reports, December, 1922.

SEISMOLOGICAL REPORTS FOR JANUARY, 1923.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, March 3, 1923.]

SEISMOLOGICAL ABBREVIATIONS USED IN THE INSTRUMENTAL REPORTS.

CHARACTER OF THE EARTHQUAKE.

I=noticeable.
II=conspicuous.
III=strong.
d=(terræ motus domesticus)=local earthquake (sensible or felt).
v=(terræ motus vicinus)=near-by earthquake (within 1,000 km.).
r=(terræ motus remotus)=distant earthquake (1,000 to 5,000 km. distant).
u=(terræ motus ultimus)=very distant earthquake (beyond 5,000 km.).
Δ=distance to epicenter.

PHASES.

P=(undæ primæ)=first preliminary tremors.
PR_n=P waves reflected n times at the earth's surface.
S=(undæ secundæ)=second preliminary tremors.
SR_n=S waves reflected n times at the earth's surface.
PS=transformed waves; longitudinal (P) to transverse (S) or vice versa.
L=(undæ longæ)=long waves in the principal portion.
M=(undæ maximæ)=greatest motion in the principal portion.
C=(coda)=trailers.
O=time at epicenter.
L_{rep_1}=long waves reaching the station from the antiepicenter (40,000 km.$-\Delta$).
L_{rep_2}=long waves again reaching the station from the antiepicenter (40,000 km.$+\Delta$).
F=(finis)=end of perceptible trace.

NATURE OF THE MOTION.

i=(impetus)=abrupt beginning.
e=(emersio)=gradual appearance.
T=(period)=twice time of oscillation.
A=amplitude of earth's movement, reckoned from the zero line. E, N, or Z attached to a symbol signifies the E–W, the N–S, or the vertical component, respectively, thus:
P_E is the E–W component of P.
P_N is the N–S component of P.
P_Z is the vertical component of P.
μ=micron, $\frac{1}{1000}$ mm.

INSTRUMENTAL CONSTANTS.

T_0=period of instrument.
V=magnification of instrument.
ϵ=damping ratio.

List of instrumental stations from which reports are received.

Location.	Latitude, N.	Longitude, W.	Elevation, meters.	Description of instruments.	Instrumental constants. E-W. V	E-W. T_0	E-W. e	N-S. V	N-S. T_0	N-S. e	Institution.	Director.
ALABAMA.												
Mobile	30 41 44	88 08 46	60	Wiechert 80-kg., two comp., inverted pendulum.	.....	.....	.....	.....	.....	.....	Spring Hill College, Seismic Observatory.	Cyril Ruhlmann, S. J.
ALASKA.												
Sitka	57 03	135 20 06	15.2	Bosch-Omori 10-kg., horizontal pendulum, two comp.	10	22.1	.....	10	18.2	.....	U. S. Coast and Geodetic Survey, Magnetic Observatory.	F. P. Ulrich.
ARIZONA.												
Tucson	32 14 48	110 50 06	769.6	.....do.....	10	16.7	.....	10	19.4	.....	.....do.....	A. K. Ludy.
CALIFORNIA.												
Point Loma	32 42 03	117 15 10	91.4	Two-component C. D. West seismoscope.	.....	.....	.....	.....	.....	.....	Theosophical University, Meteorological Station.	F. J. Dick.
COLORADO.												
Denver	39 40 36	104 56 54	1,655	Wiechert 80-kg., astatic horizontal pendulum.	.....	.....	.....	.....	.....	.....	Regis College, Earthquake Station.	A. W. Forstall, S. J.
DISTRICT OF COLUMBIA.												
Washington	38 54 25	77 04 24	42.4	Wiechert 200-kg., inverted pendulum; *80-kg. vertical.*	165	5.4	0	142	5.2	0	Georgetown University, Seismological Station.	F. A. Tondorf, S. J.
					VERTICAL: *V, 80; T_0, 3.0.*							
				Bosch photographic pendulums (horizontal), 200 g.	133	5.0	.....	133	5.0	.....		
				Mainka bifilar pendulums, 135-kg., horizontal.	47	9.0	.....	59	9.0	.....		
				Bosch-Omori 25-kg., horizontal.	13.7	8.8	.....	13.5	8.6	.....		
Washington	38 54 12	77 03 03	21	Marvin, inverted pendulum, undamped, mechanical registration.	110	6.4	[3]	110	6.4	.....	U. S. Weather Bureau	W. J. Humphreys.
HAWAII.												
Honolulu	21 19 12	158 03 48	15.2	Milne-Shaw	150	12	[5] 25:1	150	12	[5] 25:1	U. S. Coast and Geodetic Survey, Magnetic Observatory.	H. E. McComb.
ILLINOIS.												
Chicago	41 47	87 37	180.1	Two Milne-Shaw horizontal pendulums, 0.45-kg.	150	12	[2] 20:1	150	12	[2] 20:1	U. S. Weather Bureau, University of Chicago.	H. J. Cox.
MARYLAND.												
Cheltenham	38 44	76 50 30	*ca.* 71.6	Two Bosch-Omori 10-kg.	10	15	.....	10	15	.....	U. S. Coast and Geodetic Survey, Magnetic Observatory.	George Hartnell.
MASSACHUSETTS.												
Cambridge	42 22 36	71 06 59	5.4	Two Bosch-Omori 100-kg., horizontal pendulum, mechanical registration.	80	23	1:5	50	25	[4] 1:5	Harvard University Seismographic Station.	J. B. Woodworth.
MISSOURI.												
St. Louis	38 38 17	90 13 58.3	160.4	Wiechert 80-kg., inverted pendulum.	80	7	5:1	.....	.....	.....	St. Louis University, Geophysical Observatory, Earthquake Station.	Geo. E. Rueppel.
NEW YORK.												
Ithaca	42 26 58	76 29 09	242.6	Bosch-Omori 25-kg., horizontal pendulum, mechanical registration.	12	21	4:1	13	24	4:1	Cornell University, Department of Geology, Seismograph Station.	P. S. Sheldon.
New York	40 51 47	73 53 08	23.9	Wiechert 80-kg., horizontal pendulum.	80	70	5	80	70	5	Fordham University, Seismologic Station.	J. J. Lynch, S. J.
CANAL ZONE.												
Balboa Heights	8 57 39	79 33 29	*ca.* 36	Two Bosch-Omori 100-kg. and 25-kg.	35 10	20	.....	35 10	20 20	.....	Panama Canal, Department Operation and Maintenance, section of meteorology and hydrography, Seismologic Station.	R. Z. Kirkpatrick, chief hydrographer.
PORTO RICO.												
Vieques	18 08 50	65 26 50	19.1	Bosch-Omori 10-kg.	10	17.2	.....	10	19.1	.....	U. S. Coast and Geodetic Survey. Magnetic Observatory.	R. R. Bodle.
VERMONT.												
Northfield	44 10	72 41	256	Bosch-Omori, mechanical registration, 25-kg.	10	15	.....	10	16	.....	Local office, U. S. Weather Bureau.	Wm. A. Shaw.
CANADA.												
Ottawa	45 23 38	75 42 57	83	Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80-kg. vertical seismograph.	120	26	.....	.....	.....	.....	Dominion Observatory, Earthquake Station.	E. A. Hodgson.
Toronto	43 40 01	79 23 54	113.7	Milne horizontal pendulum, North, in the meridian.	.....	18	10".46	.....	.....	.....	Dominion Meteorological Service.	
Victoria	48 24	123 19	67	Milne-Shaw horizontal pendulum, North and E.-W.	.....	.....	.....	.....	.....	.....	.....do.....	

[1] Pillar inclination, 1 mm. [2] 1" arc tilt, 26.6 mm. [3] 1 mm.=4". [4] 15 mm.=60 sec. [5] Sensitivity: E, 0.182; N, 0.196.

For the reports of the stations at the University of California, Berkeley, Calif., and at the Lick Observatory, Mount Hamilton, Calif., see *Bulletin of the Seismographic Station University of California;* for the report of the station at the University of Santa Clara, Santa Clara, Calif., see *Record of the Seismographic Station, University of Santa Clara.*

TABLE 1.—*Noninstrumental earthquake reports.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1923.	*H. m.*		° ′	° ′			*Sec.*			
11	4 30	Cedarville	41 30	120 05		1	30	Faint	Felt by several	Johnstone Co.
15	22 00	Cloverdale	38 45	123 00	3	1		None	do	J. O. Ogle.
18	4 *ca.*	Susanville	40 30	120 40	2?	1			do	H. S. Prine.
22	9 *ca.*	Alton	40 30	124 10	7–8				Chimneys damaged	Press report.
		Ferndale	40 30	124 20	7–8				Considerable damage	Do.
		Loleta	40 40	124 15	7–8				do	Do.
		Scotia	40 30	124 05	7–8				Widespread minor damage	Do.
		Upper Mattole	40 15	124 15	7				do	Do.
	9 05	Dyerville	40 20	124 00	7–8	2	40		Considerable damage	Do.
		Eureka	40 48	124 10	6	1	20 *ca.*	Rumbling	Two faint shocks later	J. M. Jones.
		Fort Bragg	39 30	123 50	3	1	10	None	Felt by many	N. F. Fuller.
		McCloud	41 15	122 10	4	1		do	Felt by several	M. C. Gerlicher.
		Orland	39 45	122 15	6		(?)	Loud	Felt by many	H. W. Emery.
		Pepperwood	40 30	124 00	*ca.* 8				Much damage	Press report.
	9 06	Chico	39 45	121 50	2	1	5 *ca.*	None	Felt by several	Mrs. J. E. Morrow.
	9 09	Red Bluff	40 10	122 15	5–6			Rumbling	Felt by everyone	H. J. Andree.
		Willows	34 03	118 15	5	3	6, 2, 2	Rattling	Felt by many	J. T. McPherson.
	9 10	Fort Ross	38 30	123 15	4	1		None	Felt by several	C. A. Call.
		Nevada City	39 15	121 00		1		do	do	B. H. Preston.
		Petrolia	40 15	124 20	7–8			Yes	Considerable damage	M. Langdon.
	9 15	Redding	40 35	122 25	3		30–60	Rumbling	Felt by many	G. Albro.
		OREGON.								
11	4 23	Valley Falls	42 20	120 20	5	1	60	do	Felt by several	C. W. E. Jennings.
	4 30	Lakeview	42 10	120 20	6?				Shocks at 6:15, 7:45	C. C. Gott.
		WYOMING.								
17	20 02	Bighorn	44 40	107 00	4	1	40	Rumbling		Mr. Perry.
	20 05	do	44 40	107 00	3	3	14	do	Felt by several	Mrs. Emma Sackett.

TABLE 2.—*Instrumental seismological reports, January, 1923.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*								
1923 Jan. 22	.....	O.....	*H. m. s.* 9 03 59	*Sec.*	μ	μ	*K'm.* 2,140	
		P.....	9 08 27	.....	.....	.....	.....	
		iS_E....	9 12 02	32	.....	.....	.....	
		Li_E...	9 12 35	.....	.....	.....	.....	
		$L2_E$...	9 16 08	.....	.....	.....	.....	
		L_N....	9 14 39	.....	.....	.....	.....	
		M_E....	9 17 03	18	*5,000	.....	.....	
		M_N....	9 17 25	16	.....	*2,700	.....	
		C_E....	9 25 ..	.....	.....	.....	.....	
		F_E....	10 48 ..	.....	.....	.....	.....	
		F_N....	10 54 ..	.....	.....	.....	.....	
ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*								
1923 Jan. 11	.....	e.....	*H. m. s.* 4 35 18	*Sec.*	μ	μ	*Km.*	Local tremors.
		L.....	4 35 41	4	.....	.....	.....	
		M_E....	.....	.....	*100	.....	.....	
		M_N....	4 35 44	.....	.....	*100	.....	
		F.....	4 40 ..	.....	.....	.....	.....	
22	.....	O.....	9 04 18	.....	.....	.....	1,550	Recorded on magnetograph.
		iP.....	9 07 38	3	.....	.....	.....	
		S_N....	9 10 20	.....	.....	.....	.....	
		L_E1...	9 10 43	.....	.....	.....	.....	
		L_E2...	9 11 43	.....	.....	.....	.....	
		L_E3...	9 12 46	.....	.....	.....	.....	
		iL_N1..	9 10 43	.....	.....	.....	.....	
		L_N2...	9 11 36	.....	.....	.....	.....	
		M_E....	9 13 12	16	*20800	.....	.....	
		M_N....	9 13 15	15	.....	*29000	.....	
		C_N....	9 15 ..	.....	.....	.....	.....	
		F_E....	10 02 ..	.....	.....	.....	.....	
		F_N....	9 54 ..	.....	.....	.....	.....	
27	.....	P_E....	7 59 47	2	.....	.....	.....	Recorded on the magnetograph.
		S.....	8 01 12	13	.....	.....	.....	
		L_E....	8 02 04	.....	.....	.....	.....	
		L_E....	8 01 30	.....	.....	.....	.....	
		M_E....	8 02 05	.....	*1,500	.....	.....	
		M_N....	8 01 53	8	.....	*2,000	.....	
		F.....	8 14 ..	.....	.....	.....	.....	
COLORADO. *Regis College, Denver.*								
1923 Jan. 22	.....	P.....	*H. m. s.* 9 07 30	*Sec.*	μ	μ	*Km.*	Difficult to locate beginning of S.
		S.....	9 10 30	.....	.....	.....	.....	
		L.....	9 12 20	5*ca*	*13,000	*27,000	.....	
		M_N....	9 13 ..	5-7	.....	*51,000	.....	
		M_E....	9 14 ..	4-5	*30,000	.....	.....	
		C.....	9 22 ..	.....	.....	.....	.....	
		F_N....	9 41 ..	.....	.....	.....	.....	
		F_E....	9 36 ..	.....	.....	.....	.....	
27	.....	L.....	9 04 ..	12	*1,000	*2,000	.....	Very regular sinusoidal.
		F_N....	9 12 ..	.....	.....	.....	.....	
		F_E....	9 11 ..	.....	.....	.....	.....	
DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*								
1923. Jan. 11	.....	e.....	*H. m. s.* 4 45 45	*Sec.*	μ	μ	*K'm.*	
		F.....	4 50 ..	.....	.....	.....	.....	
22	.....	P.....	9 11 02	.....	.....	.....	4,000	
		S.....	9 16 47	.....	.....	.....	.....	
		L.....	9 21 15	.....	.....	.....	.....	
		M_N....	9 25 ..	.....	.....	*55,000	.....	
		M_E....	9 27 ..	.....	*16,000	.....	.....	
		F.....	10 17 *ca.*	.....	.....	.....	.....	
27	.....	P.....	8 07 13	.....	.....	.....	.....	
		S.....	8 10 28	.....	.....	.....	.....	
		F.....	8 45 *ca.*	.....	.....	.....	.....	

*Trace amplitude.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

1923.			*H. m. s.*	*Sec.*	μ	μ	*K'm.*	
Jan. 2	.....	L_N....	23 57 02	10	.....	.....	.....	E record obscured by overlapping of traces.
3	.....	M_N....	0 00 18	8	.....	25	.....	
		F_N....	0 19 ..	.....	.....	.....	.....	
8	.....	e_N.....	22 09 10	.....	.....	.....	.....	Do.
		M_N....	22 11 50	.....	.....	*2,000	.....	
		F_N....	22 16 ..	.....	.....	.....	.....	
14	.....	P_E....	12 59 40	2	.....	.....	.....	Local shock; felt in all parts of Oahu. Recorded on the magnetograph.
		P_N(?).	12 59 18	2	.....	.....	.....	
		L_E....	12 59 50	6	.....	.....	.....	
		L_N....	12 59 55	6	.....	.....	.....	
		M_E....	13 01 40	6	82	.....	.....	
		M_N....	13 01 45	6	.....	104	.....	
		C_E....	13 03 ..	.....	.....	.....	.....	
		C_N....	13 02 ..	.....	.....	.....	.....	
		F_E....	13 10 ..	.....	.....	.....	.....	
		F_N....	13 15 ..	.....	.....	.....	.....	
22	.....	e_E.....	1 10 34	.....	.....	.....	.....	Mere trace of activity on N.
		M_E....	1 14 32	.....	*2,300	.....	.....	
		F_E....	1 22 ..	.....	.....	.....	.....	
22	.....	O.....	9 04 12	.....	.....	.....	3,800	Recorded on magnetograph.
		P.....	9 11 15	.....	.....	.....	.....	
		PR....	9 12 28	.....	.....	.....	.....	
		e_E.....	9 15 40	.....	.....	.....	.....	
		e_N.....	9 15 35	.....	.....	.....	.....	
		S_E.....	9 16 50	.....	.....	.....	.....	
		SR_E...	9 18 35	.....	.....	.....	.....	
		L_E....	9 19 02	11	.....	.....	.....	
		iL_N...	9 18 52	8	.....	.....	.....	
		L_N2...	9 19 35	.....	.....	.....	.....	
		M_E....	9 21 49	8	176	.....	.....	
		M_N....	9 21 06	8	.....	230	.....	
		F_E....	11 16 ..	.....	.....	.....	.....	
		F_N....	11 29 ..	.....	.....	.....	.....	
27	.....	e_E.....	8 19 12	.....	.....	.....	.....	
		e_N.....	8 18 24	.....	.....	.....	.....	
		M_N....	8 19 32	10	.....	19	.....	
		F.....	8 23 ..	.....	.....	.....	.....	

ILLINOIS. *U. S. Weather Bureau, Chicago.*

1923.			*H. m. s.*	*Sec.*	μ	μ	*K'm.*	
Jan. 2	.....	P?.....	22 57 50	.....	.....	.....	.....	
		S?.....	23 01 40	.....	.....	.....	.....	
		L.....	23 06 32	20	.....	.....	.....	
		L.....	23 13 ..	15	.....	.....	.....	
3	.....	F.....	0 10 ..	.....	.....	.....	.....	
8	.....	e.....	22 17 34	.....	.....	.....	.....	
		eL....	22 19 00	.....	.....	.....	.....	
		L.....	22 22 ..	15	.....	.....	.....	
		F.....	23 10 *ca.*	.....	.....	.....	.....	
11	.....	P.....	4 38 15	.....	.....	.....	.....	
		S.....	4 41 47?	.....	.....	.....	.....	
		L.....	4 43 37	.....	.....	.....	.....	
		F.....	5 10 *ca.*	.....	.....	.....	.....	
22	.....	e.....	1 12 35	.....	.....	.....	.....	
		L.....	1 48 ..	22	.....	.....	.....	
		L.....	1 57 ...	18	.....	.....	.....	
		F.....	3 *ca.*	.....	.....	.....	.....	
22	.....	P.....	9 10 04	.....	.....	.....	3,200	
		S.....	9 14 58	.....	.....	.....	.....	
		L?.....	9 18 ..	.....	.....	.....	.....	
		F.....	11 40 *pos.*	.....	.....	.....	.....	Ran off sheet.
22	.....	eL....	14 31 ..	.....	.....	.....	.....	
		L.....	14 34 ..	18	.....	.....	.....	
		F.....	15 10 *ca.*	.....	.....	.....	.....	
27	.....	P.....	8 07 18	.....	.....	.....	1,500	
		S.....	8 09 53	.....	.....	.....	.....	
		L.....	8 10 33	.....	.....	.....	.....	
		F.....	9 05 *ca.*	.....	.....	.....	.....	
27	.....	L.....	17 19 ..	18	.....	.....	.....	Possibly not seismic.
		L.....	17 28 ..	15	.....	.....	.....	
		F.....	17 40 *ca.*	.....	.....	.....	.....	

MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*

1923			*H. m. s.*	*Sec.*	μ	μ	*K'm.*	
Jan. 22	.....	O.....	9 04 04	.....	.....	.....	4,020	Maximum N. off sheet.
		P.....	9 11 24	3	.....	.....	.....	
		S.....	9 17 12	.....	.....	.....	.....	
		Li_E...	9 23 53	.....	.....	.....	.....	
		$L2_E$...	9 27 06	.....	.....	.....	.....	
		Li_N...	9 22 39	.....	.....	.....	.....	
		$L2_N$...	9 24 27	.....	.....	.....	.....	
		M_E....	9 27 37	16	*9,000	.....	.....	
		M_N....	9 25 ..	16	.....	*52,000	.....	
		C_E....	9 29 00	.....	.....	.....	.....	
		C_N....	9 27 ..	.....	.....	.....	.....	
		F_E....	10 00 ..	.....	.....	.....	.....	
		F_N....	10 11 ..	.....	.....	.....	.....	
27	.....	e_N.....	8 13 50	.....	.....	.....	.....	Nothing definite on E.
		M_N....	8 15 36	6	.....	*200	.....	
		F_N....	8 22 ..	.....	.....	.....	.....	

* Trace amplitude.

NEW YORK. *Fordham University, New York.*

1923			H. m. s.	Sec.	μ	μ	Km.	
Jan. 22	.....	iP_E	9 11 40	.....	.....	.....	.....	
		eP_N	9 11 40	.....	.....	.....	4,060	
		$PR2?_N$	9 13 07	.....	.....	.....	.....	
		iS_N	9 17 35	.....	.....	.....	.....	
		iS_E	9 17 36	.....	.....	.....	.....	
		L_N	9 22 *ca.*	.....	.....	.....	.....	
		M_N	9 25 53	.....	.....	.....	.....	
26	.....	e_N	8 14 41	.....	.....	.....	.....	Obscured by micros.
		e_N	8 15 26	.....	.....	.....	.....	
		e_E	8 15 31	.....	.....	.....	.....	
		L_E	8 17 20	.....	.....	.....	.....	
		$L_N?$	8 18 *ca.*	.....	.....	.....	.....	
		$L_N?$	8 20 *ca.*	.....	.....	.....	.....	

CANAL ZONE. *Panama Canal, Balboa Heights.*

1923			H. m. s.	Sec.	μ	μ	Km.	
Jan. 22	.....						.....	Slight tremors from distant disturbance between 9:05 and 10:20; direction probably northerly.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1923			H. m. s.	Sec.	μ	μ	Km.	
Jan. 22	.....	O	9 04.08	.....	.....	.....	6,240	Preliminary phases very weak.
		P_N	9 13 53	3	.....	.....	.....	
		PR_E	9 17 07	.....	.....	.....	.....	
		S_E	9 22 04	.....	.....	.....	.....	
		S_N	9 21 42	.....	.....	.....	.....	
		$L1_E$	9 30 06	.....	.....	.....	.....	
		$L2_E$	9 32 07	20	.....	.....	.....	
		$L1_N$	9 32 25	.....	.....	.....	.....	
		$L2_N$	9 36 46	.....	.....	.....	.....	
		M_E	9 34 05	16	*600	.....	.....	
		M_N	9 40 23	16	.....	*600	.....	
		F_E	9 58 ..	.....	.....	.....	.....	
		F_N	9 56 ..	.....	.....	.....	.....	

VERMONT. *U. S. Weather Bureau, Northfield.*

1923			H. m. s.	Sec.	μ	μ	Km.	
Jan. 22	.....	P	9 11 34	.....	.....	.....	4,300	
		S	9 17 36	.....	.....	.....	.....	
		L	9 22 40	24	.....	.....	.....	
		M_N	9 27 ..	.....	.....	*28,000	.....	
		F	10 16 *ca.*	.....	.....	.....	.....	
27	.....	e	8 16 30	.....	.....	.....	.....	
		F	8 30 *ca.*	.....	.....	.....	.....	

CANADA. *Dominion Meteorological Service, Toronto.*

1923.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 2	.....	eL	23 13 54	.....	.....	.....	.....	
		iL	23 15 54	.....	.....	.....	.....	
		M	23 17 48	.....	*400	.....	.....	
		F	23 47 42	.....	.....	.....	.....	
8	.....	e?	22 13 48	.....	.....	.....	.....	
		L?	22 35 18	.....	*100	.....	.....	
		F	.....	.....	.....	.....	.....	
22	.....	P	9 11 42	.....	.....	.....	4,120	Northern California.
		S	9 17 36	.....	.....	.....	.....	
		i	9 20 00	.....	.....	.....	.....	
		L	9 23 18	.....	.....	.....	.....	
		L	9 24 18	.....	.....	.....	.....	
		M	9 27 42	.....	*10,000	.....	.....	
		L	9 40 30	.....	.....	.....	.....	
		eL	10 04 12	.....	.....	.....	.....	
		F	11 18 48	.....	.....	.....	.....	
27	.....	iL	8 14 42	.....	.....	.....	.....	
		M	8 14 54	.....	*400	.....	.....	
		F	8 17 12	.....	.....	.....	.....	
27	.....	iL	8 34 12	.....	.....	.....	.....	
		F	8 35 36	.....	*200	.....	.....	

* Trace amplitude.

CANADA. *Dominion Meteorological Service, Victoria.*

1923.			H. m. s.	Sec.	μ	μ	Km.	
Jan. 2	.....	P_E	22 52 03	6	.....	.....	790	
		L_E	22 53 29	15	.....	.....	.....	
		M_E	22 56 24	8	4	.....	.....	
		F_E	23 38 24	.....	.....	.....	.....	
		P_N	22 52 04	6	.....	.....	780	
		L_N	22 53 29	15	.....	.....	.....	
		M_N	22 55 09	8	5	.....	.....	
		F_N	23 36 44	.....	.....	.....	.....	
5	.....	P_E	3 30 22	12	.....	.....	410	
		L_E	3 31 17	10	.....	.....	.....	
		M_E	3 31 32	10	4	.....	.....	
		F_E	3 35 42	.....	.....	.....	.....	
		P_N	3 30 16	6	.....	.....	450	
		L_N	3 31 17	10	.....	.....	.....	
		M_N	3 31 35	10	.....	4	.....	
5		F_N	3 35 57	.....	.....	.....	.....	
		L_E	18 33 22	20	.....	.....	.....	
		M_E	18 36 37	20	.....	6	.....	
		F_E	19 08 32	.....	.....	.....	.....	
		L_N	18 28 57	30	.....	.....	.....	
		M_N	18 30 52	20	3	.....	.....	
		F_N	19 12 57	.....	.....	.....	.....	
8	.....	P_E	22 05 13	6	.....	.....	710	
		S_E	22 06 31	9	.....	.....	.....	
		L_E	22 08 21	20	.....	.....	.....	
		M_E	22 09 41	15	5	.....	.....	
		F_E	22 31 11	.....	.....	.....	.....	
		L_N	22 08 21	20	.....	.....	.....	
		M_N	22 09 36	15	.....	.....	.....	
11	.....	$P?_E$	4 31 07	3	.....	.....	480	
		L_E	4 32 00	10	.....	.....	.....	
		M_E	4 33 00	10	5	.....	.....	
		F_E	4 43 05	.....	.....	.....	.....	
		P_N	4 30 40	5	.....	.....	720	
		L_N	4 31 59	10	.....	.....	.....	
		M_N	4 33 05	10	.....	6	.....	
		F_N	4 43 25	.....	.....	.....	.....	
12	.....	L_E	2 40 34	20	.....	.....	.....	May be long period micros.
		M_E	2 45 34	20	6	.....	.....	
		F_E	2 49 54	.....	.....	.....	.....	
		L_N	2 41 29	20	.....	.....	.....	
		M_N	2 43 24	20	.....	6	.....	
		F_N	2 48 59	.....	.....	.....	.....	
13	.....	L_E	?11 02 23	20	.....	.....	.....	Do.
		M_E	11 18 28	20	3	.....	.....	
		F_E	11 27 53	.....	.....	.....	.....	
		M_N	?11 18 27	20	.....	2	.....	
14	.....	L_E	13 17 18	20	.....	.....	.....	
		M_E	13 21 07	15	7	.....	.....	
		F_E	13 25 53	.....	.....	.....	.....	
		L_N	13 17 18	.....	.....	.....	.....	
		M_N	?13 21 08	.....	.....	6	.....	No further returns received after Jan. 20.

* Trace amplitude.

No earthquakes were recorded during January, 1923, at the following stations:

CALIFORNIA. *Theosophical University*, Point Loma.

Reports for January, 1923, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.
DISTRICT OF COLUMBIA. *Georgetown University*, Washington.
MASSACHUSETTS. *Harvard University*, Cambridge.
MISSOURI. *St. Louis University*, St. Louis.
NEW YORK. *Cornell University*, Ithaca.
CANADA. *Dominion Observatory*, Ottawa.

Chart I. Tracks of Centers of Anticyclones, January, 1923. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

Chart I. Tracks of Centers of Anticyclones, January, 1923. (Inset) Departure of Monthly Mean Pressure from Normal.
(Plotted by Wilfred P. Day.)

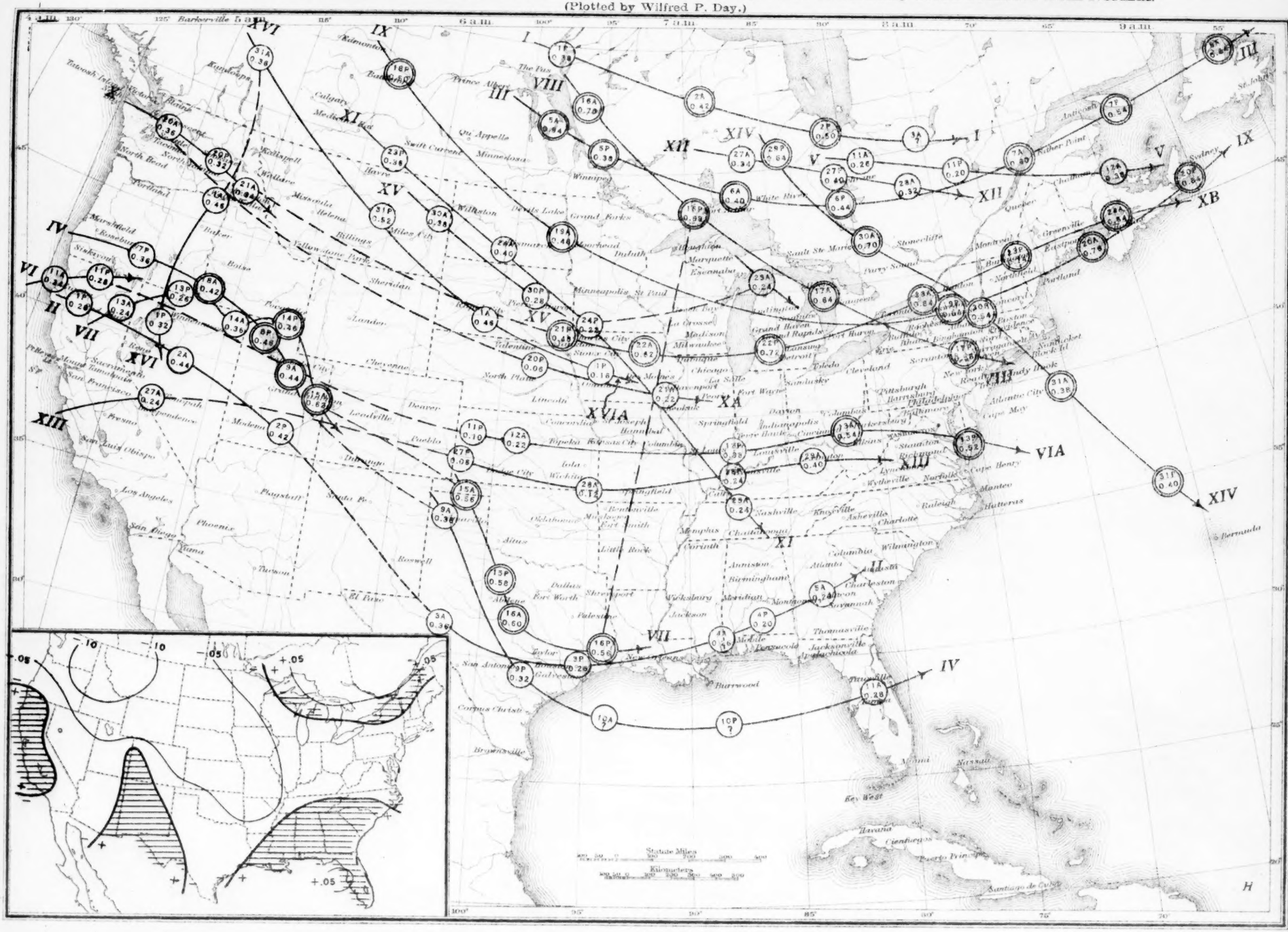

I
II
III
IV
V
VI
VII
VIII
IX
X
XB
XI
XII
XIII
XIV
XV
XVI
XVIA
XA
Statute Miles
Kilometers
Barkerville
Edmonton
Calgary
Medicine Hat
Prince Albert
Winnipeg
Swift Current
Minnedosa
Havre
Williston
Devils Lake
Grand Forks
Duluth
Minneapolis
St Paul
Marquette
Escanaba
Sault Ste Marie
Parry Sound
Stonecliffe
Montreal
Quebec
Father Point
Sydney
Yellowstone Park
Billings
Helena
Miles City
Butte
Boise
Spokane
Portland
Marshfield
Roseburg
Siskiyou
Sheridan
Lander
Cheyenne
North Platte
Denver
Leadville
Pueblo
Lincoln
Topeka
Kansas City
Omaha
Des Moines
Chicago
La Salle
Milwaukee
Detroit
Toledo
Cleveland
Sandusky
Fort Wayne
Springfield
Indianapolis
Columbus
Dayton
Pittsburgh
Harrisburg
Philadelphia
Atlantic City
Cape May
New York
Block Isl
Portland
Boston
Concordia
Hannibal
St Louis
Louisville
Cincinnati
Washington
Richmond
Norfolk
Cape Henry
Kitty Hawk
Cape Hatteras
Lynchburg
Roanoke
Knoxville
Asheville
Charlotte
Raleigh
Wilmington
Nashville
Memphis
Corinth
Chattanooga
Atlanta
Columbia
Charleston
Savannah
Jacksonville
Tallahassee
Apalachicola
Pensacola
Montgomery
Meridian
Vicksburg
Shreveport
Fort Worth
Dallas
Abilene
Palestine
Jackson
Little Rock
Fort Smith
Oklahoma
Wichita
Iola
Kansas City
Topeka
Omaha
Des Moines
Chicago
Milwaukee
Detroit
Toledo
Cleveland
Sandusky
Fort Wayne
Springfield
Indianapolis
Columbus
Dayton
Pittsburgh
Harrisburg
Philadelphia
Atlantic City
Cape May
New York
Block Isl
Portland
Boston
Montreal
Quebec
Father Point
Sydney
Yellowstone Park
Billings
Helena
Miles City
Butte
Boise
Spokane
Portland
Marshfield
Roseburg
Siskiyou
Sheridan
Lander
Cheyenne
North Platte
Denver
Leadville
Pueblo
Lincoln
Topeka
Kansas City
Omaha
Des Moines
Chicago
La Salle

Chart II. Tracks of Centers of Cyclones, January, 1923. (Inset) Change in Mean Pressure from Preceding Month.

(Plotted by Wilfred P. Day.)

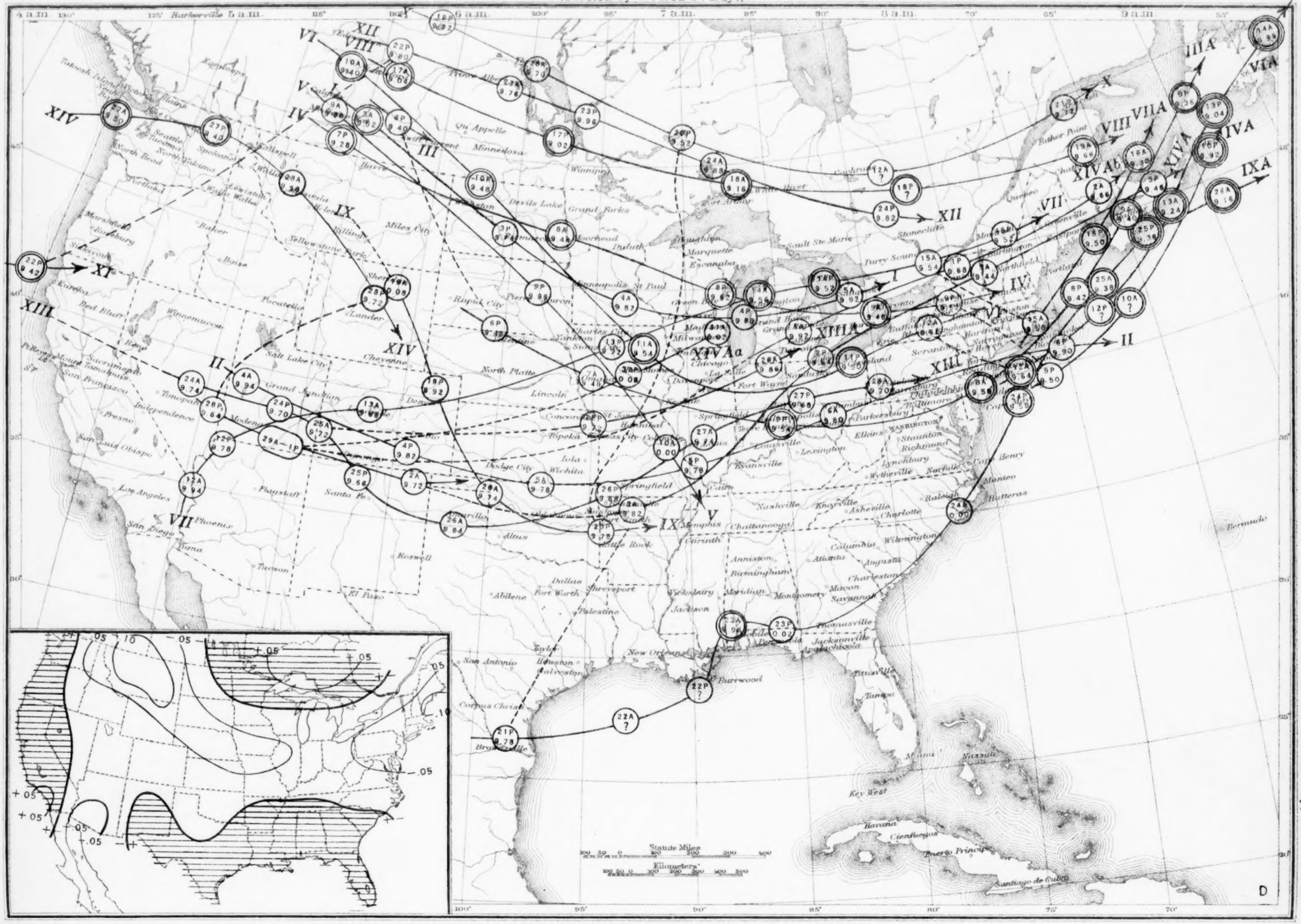


Chart III. Departure (°F.) of the Mean Temperature from the Normal, January, 1923.

Chart III. Departure (°F.) of the Mean Temperature from the Normal, January, 1923.

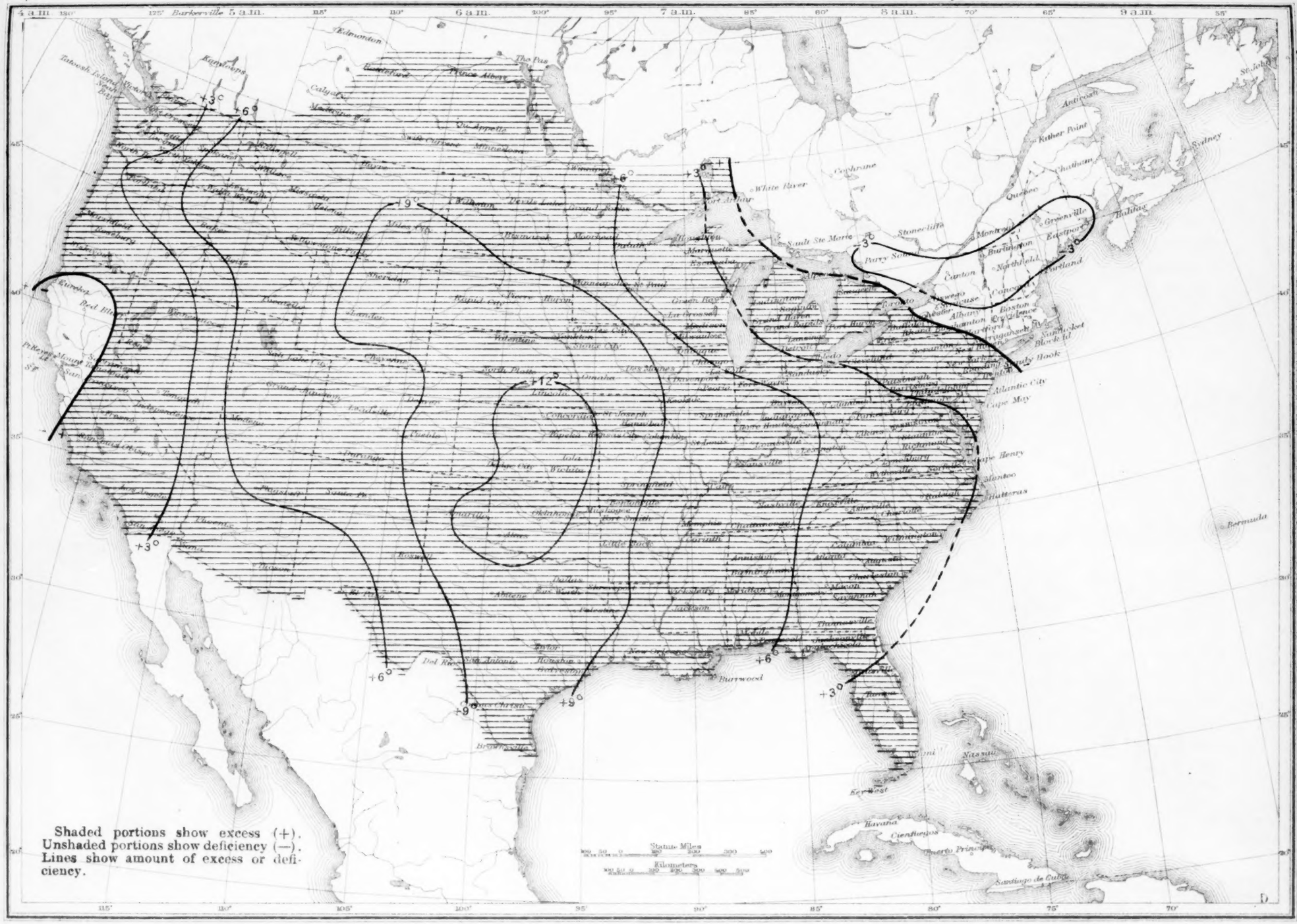

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

Chart IV. Total Precipitation, Inches, January, 1923. (Inset) Departure of Precipitation from Normal.

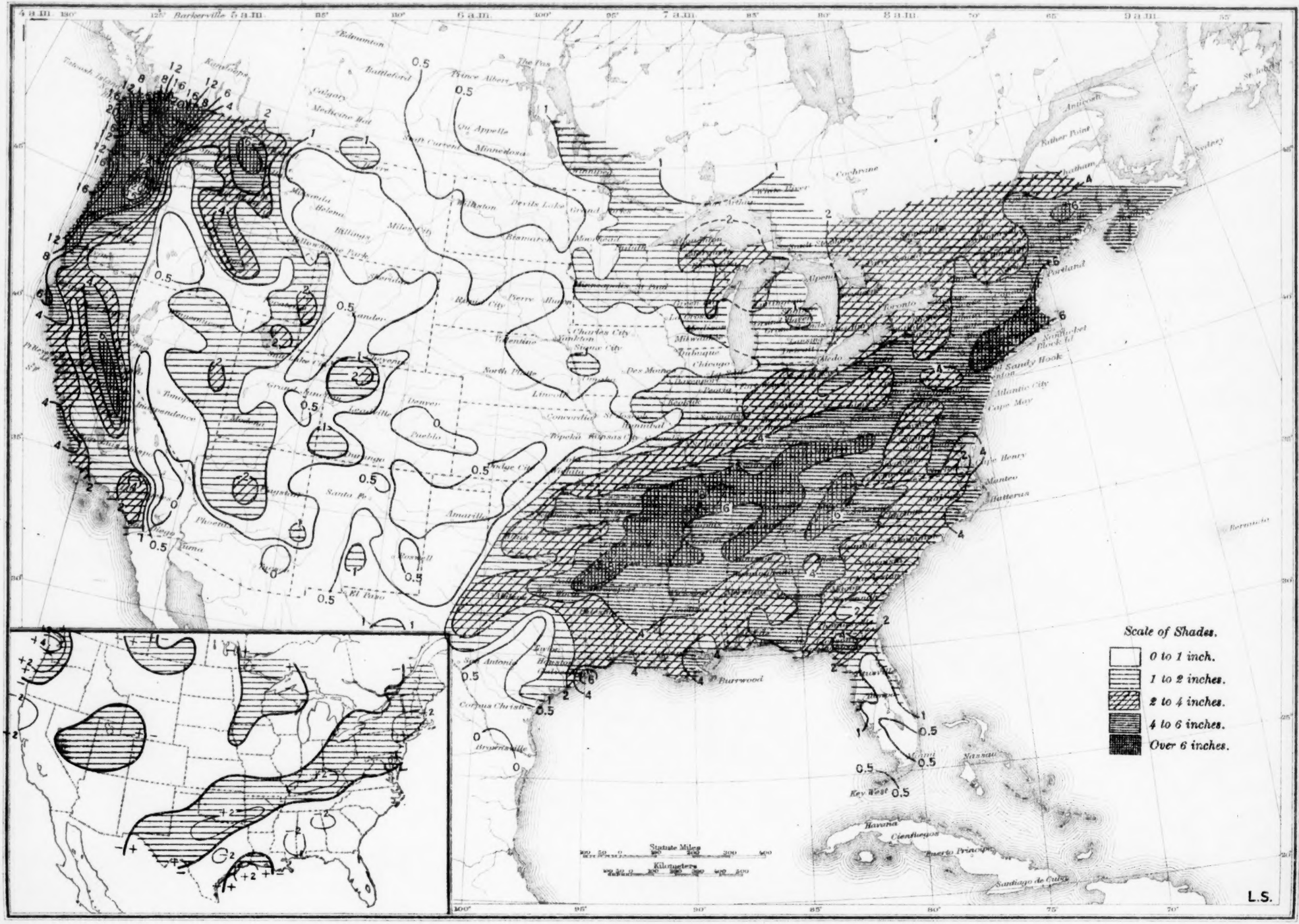


Chart V. Percentage of Clear Sky between Sunrise and Sunset, January, 1923.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, January, 1923.

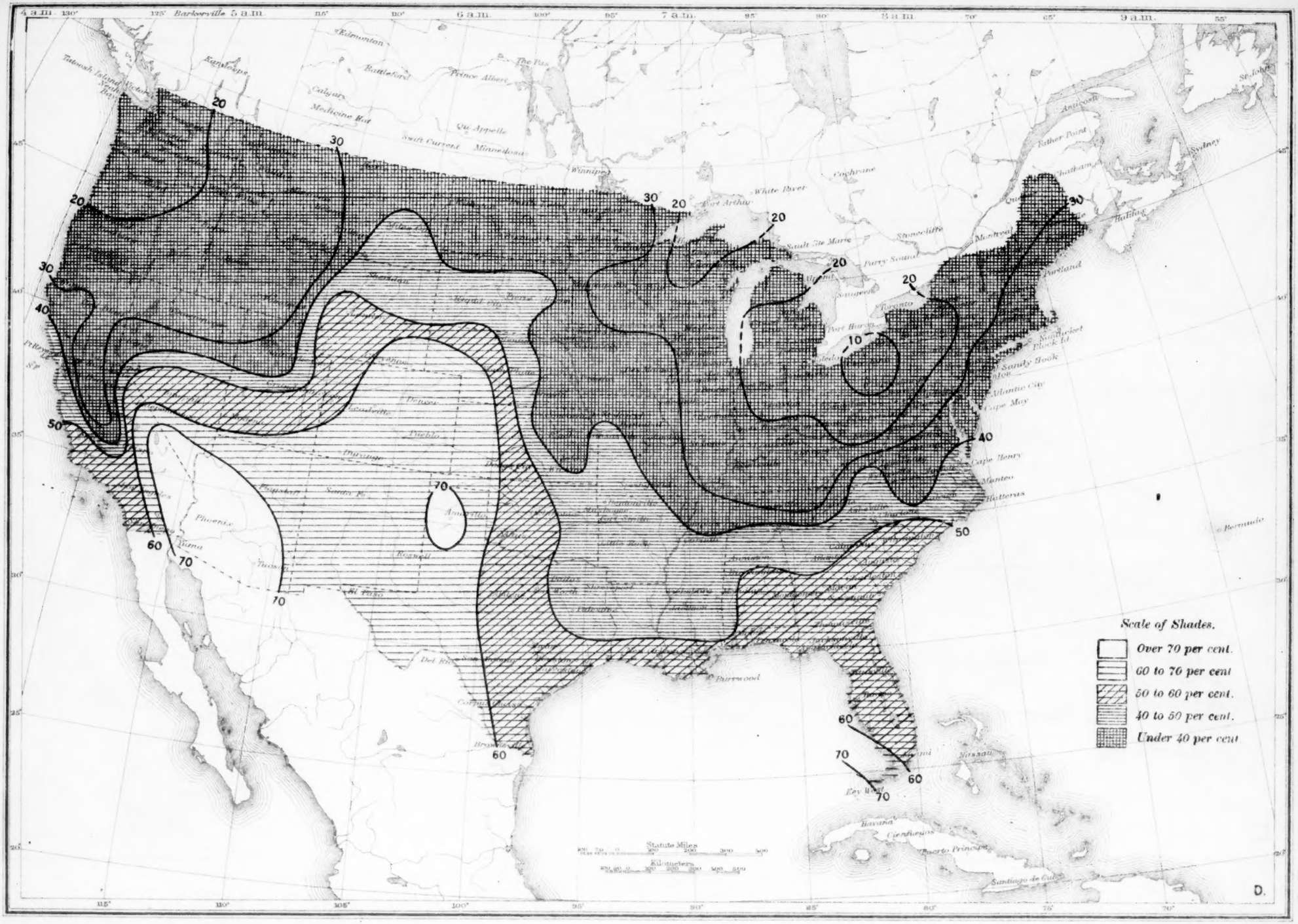


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, January, 1923.

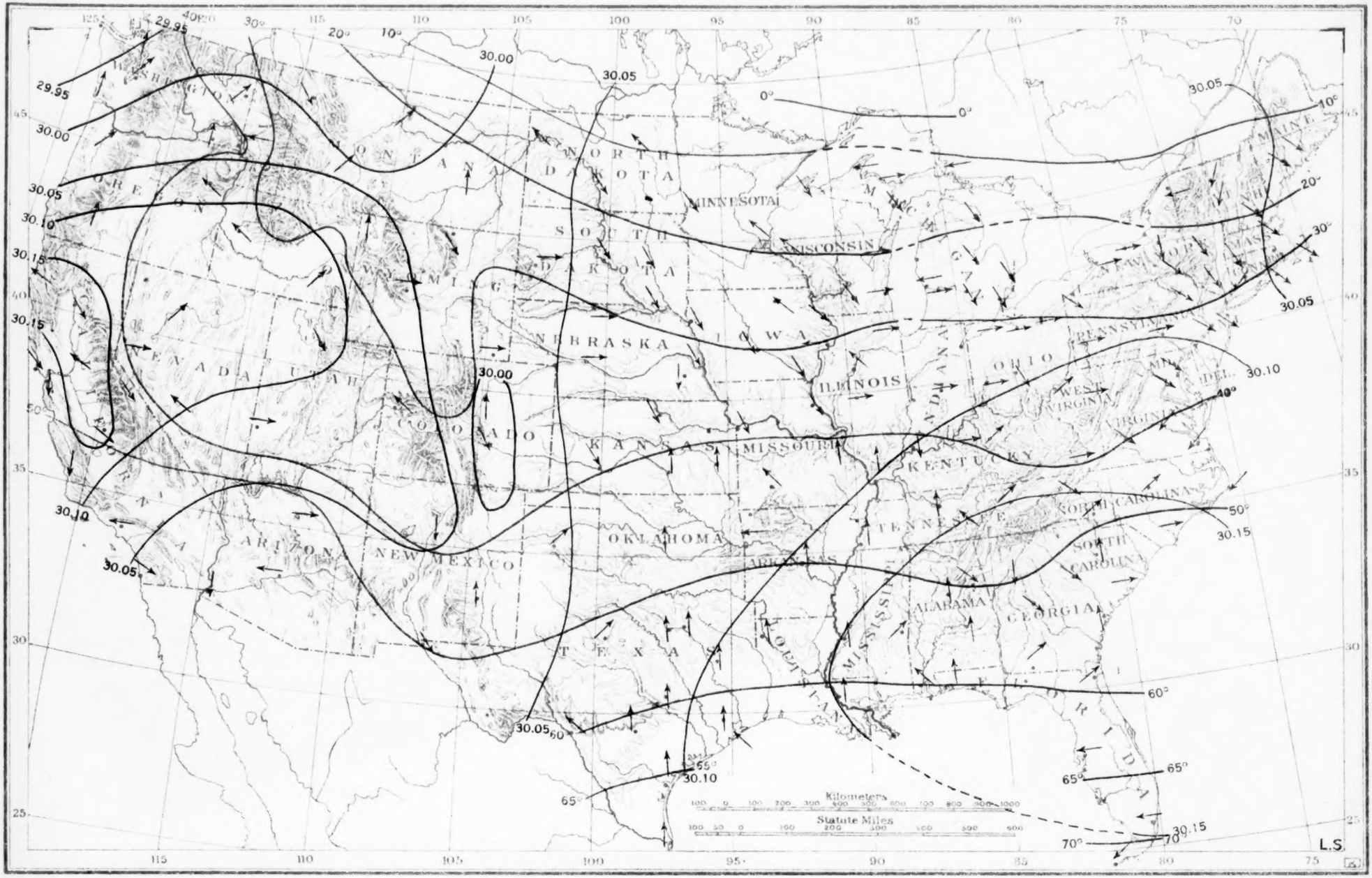


Chart VII. Total Snowfall, Inches, January, 1923.

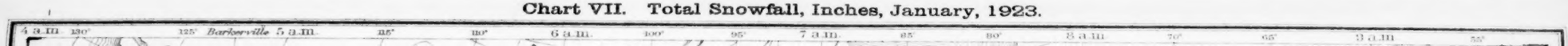


Chart VII. Total Snowfall, Inches, January, 1923.

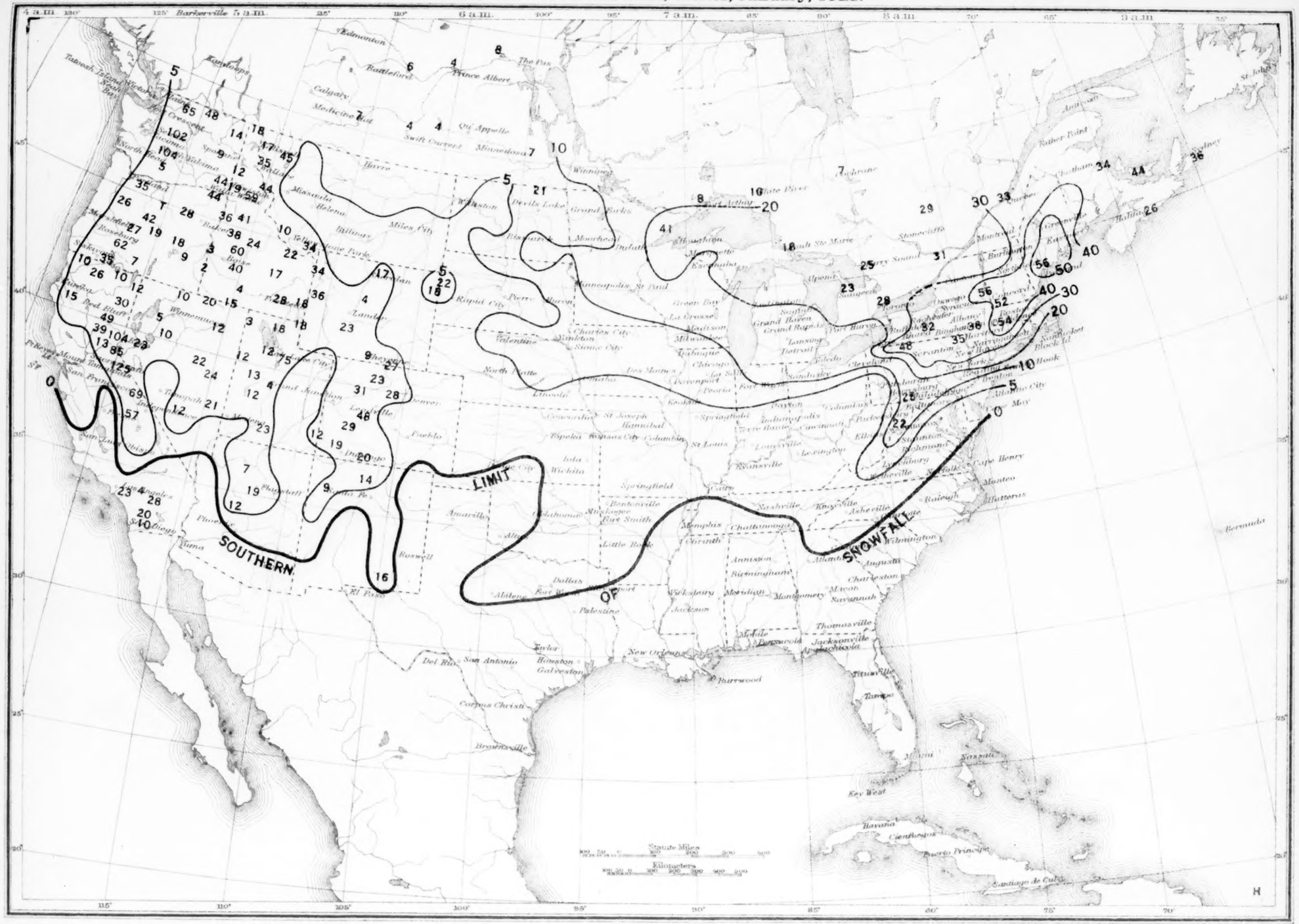


Chart VIII. Weather Map of North Atlantic Ocean, January 13, 1923.
(Plotted by F. A. Young.)

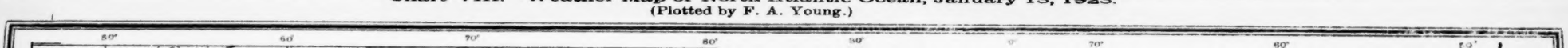


Chart VIII. Weather Map of North Atlantic Ocean, January 13, 1923.
(Plotted by F. A. Young.)

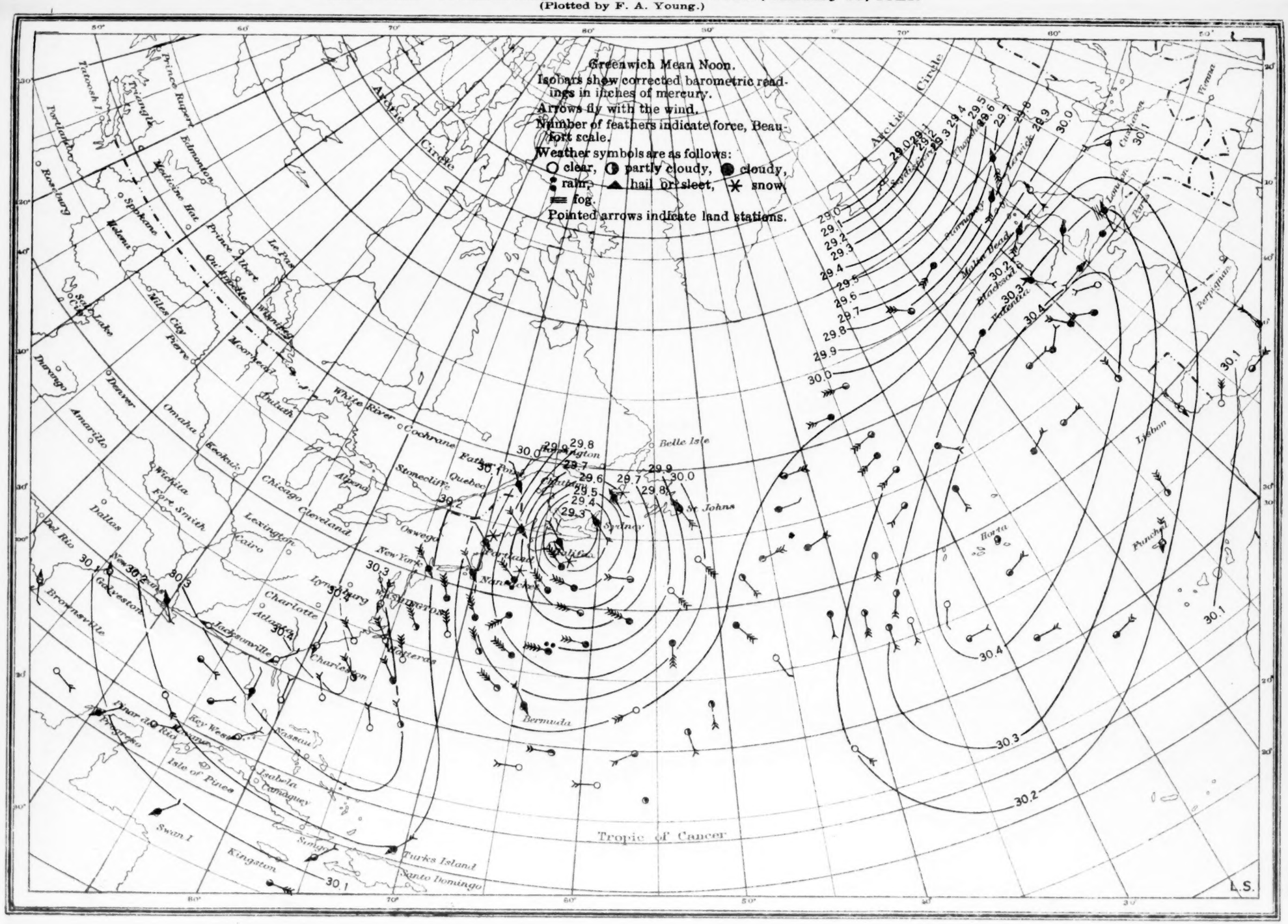


Chart IX. Weather Map of North Atlantic Ocean, January 14, 1923.

(Plotted by F. A. Young.)

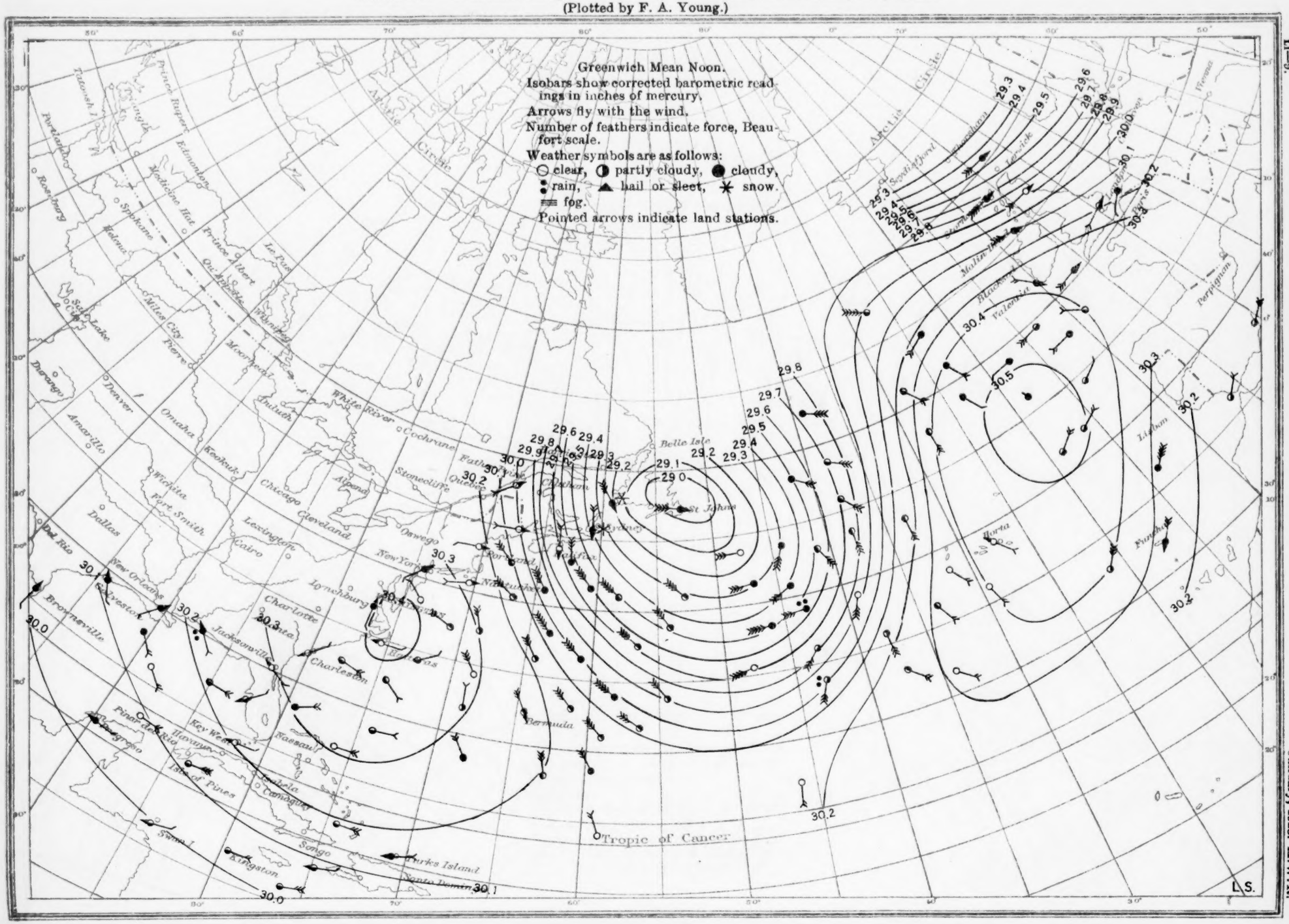

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow.
fog.
Pointed arrows indicate land stations.
Tropic of Cancer
L.S.

Chart X. Weather Map of North Atlantic Ocean, January 15, 1923.

(Plotted by F. A. Young.)

Chart X. Weather Map of North Atlantic Ocean, January 15, 1923.
(Plotted by F. A. Young.)

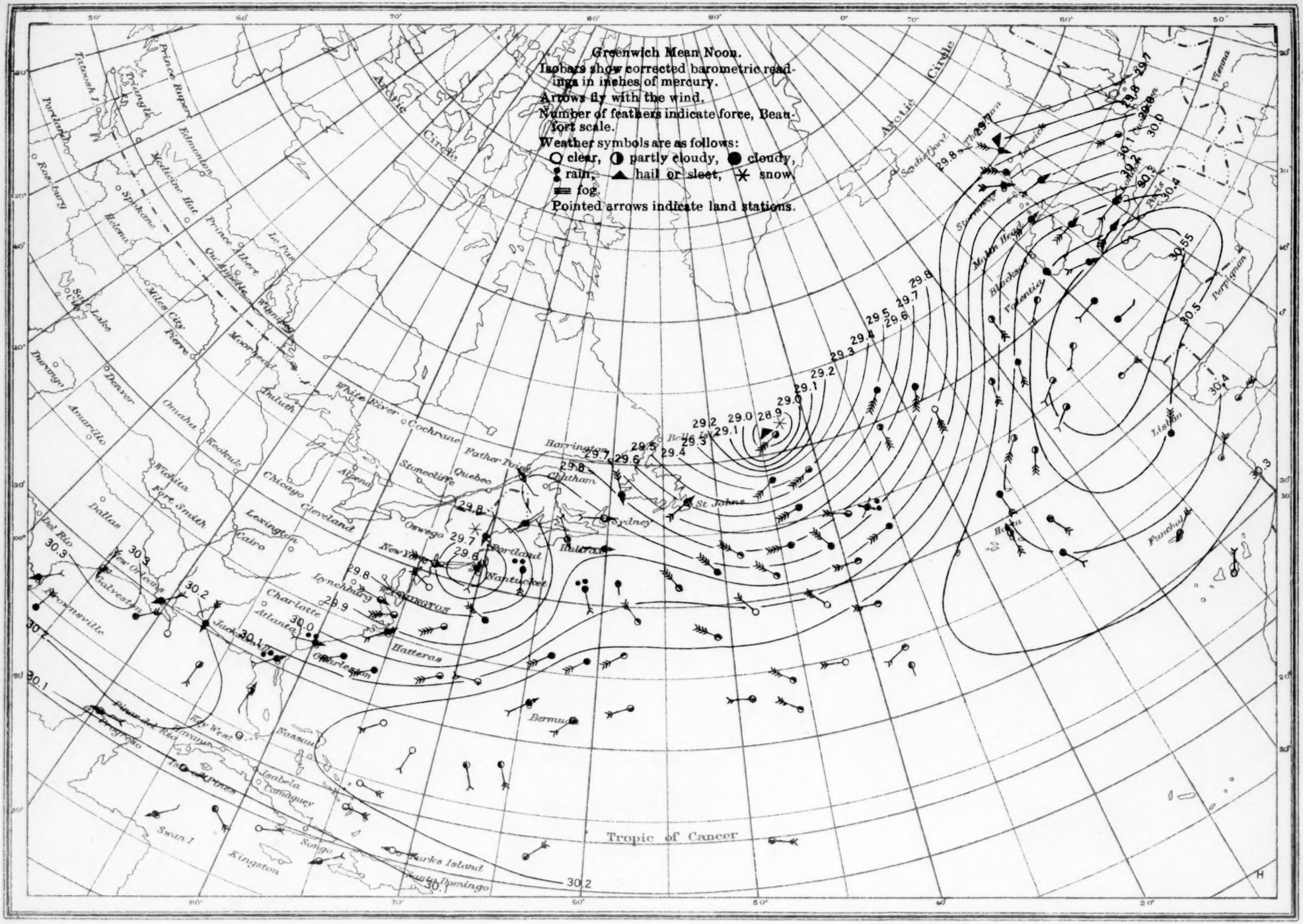


Chart XI. Weather Map of North Atlantic Ocean, January 24, 1923.

(Plotted by F. A. Young.)

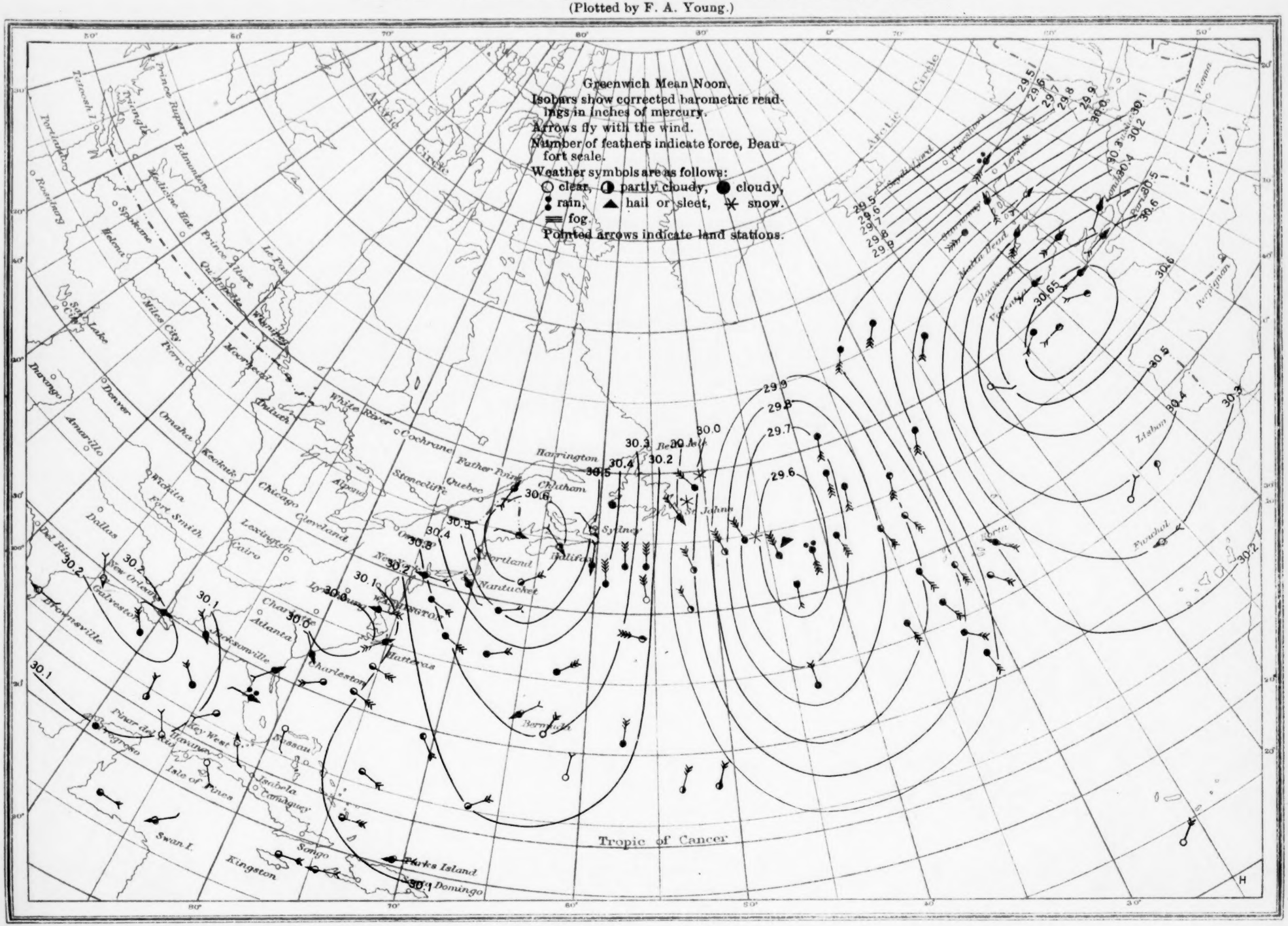


Chart XII. Weather Map of North Atlantic Ocean, January 25, 1923.

(Plotted by F. A. Young.)

Chart XII. Weather Map of North Atlantic Ocean, January 25, 1923.
(Plotted by F. A. Young.)

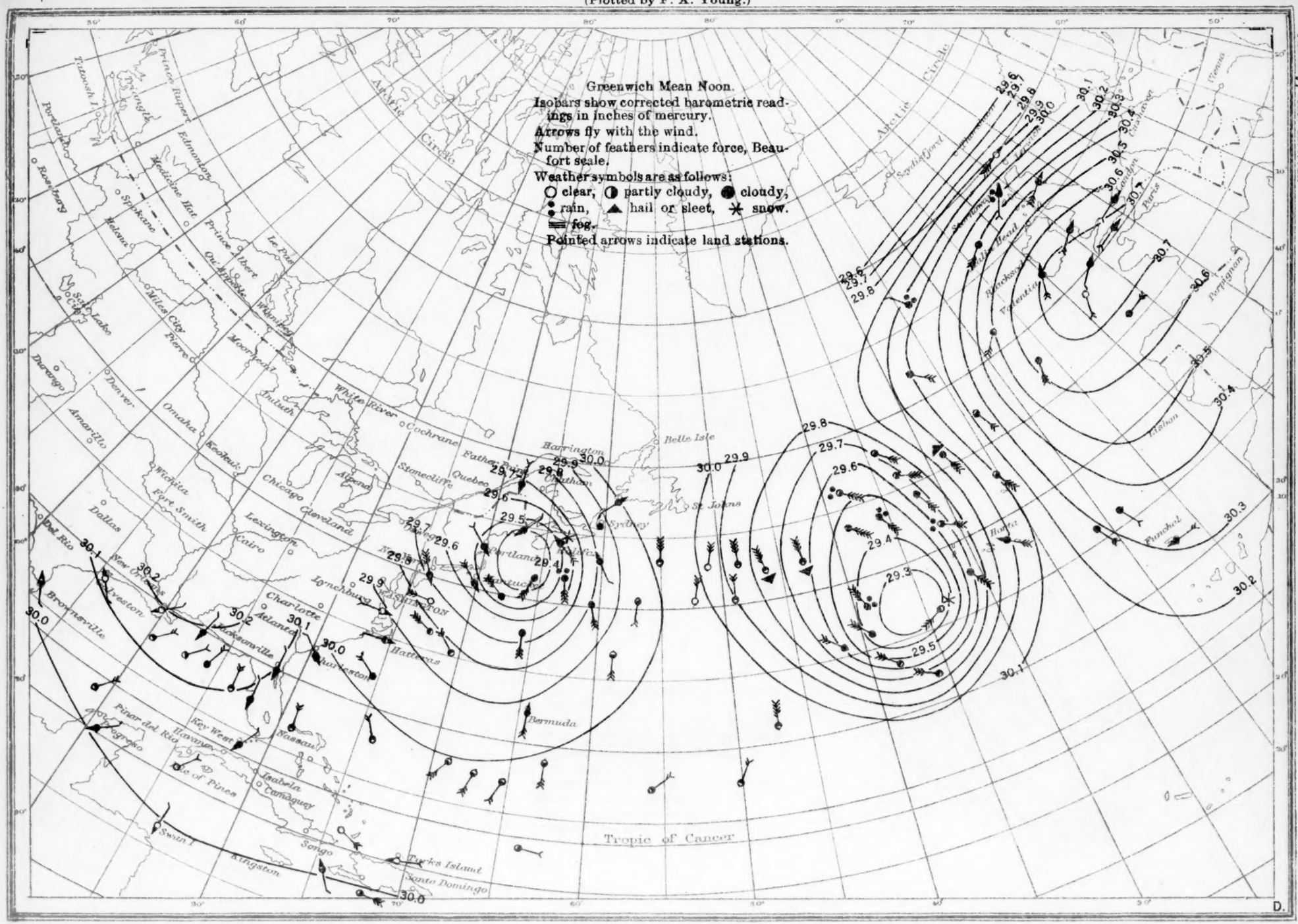
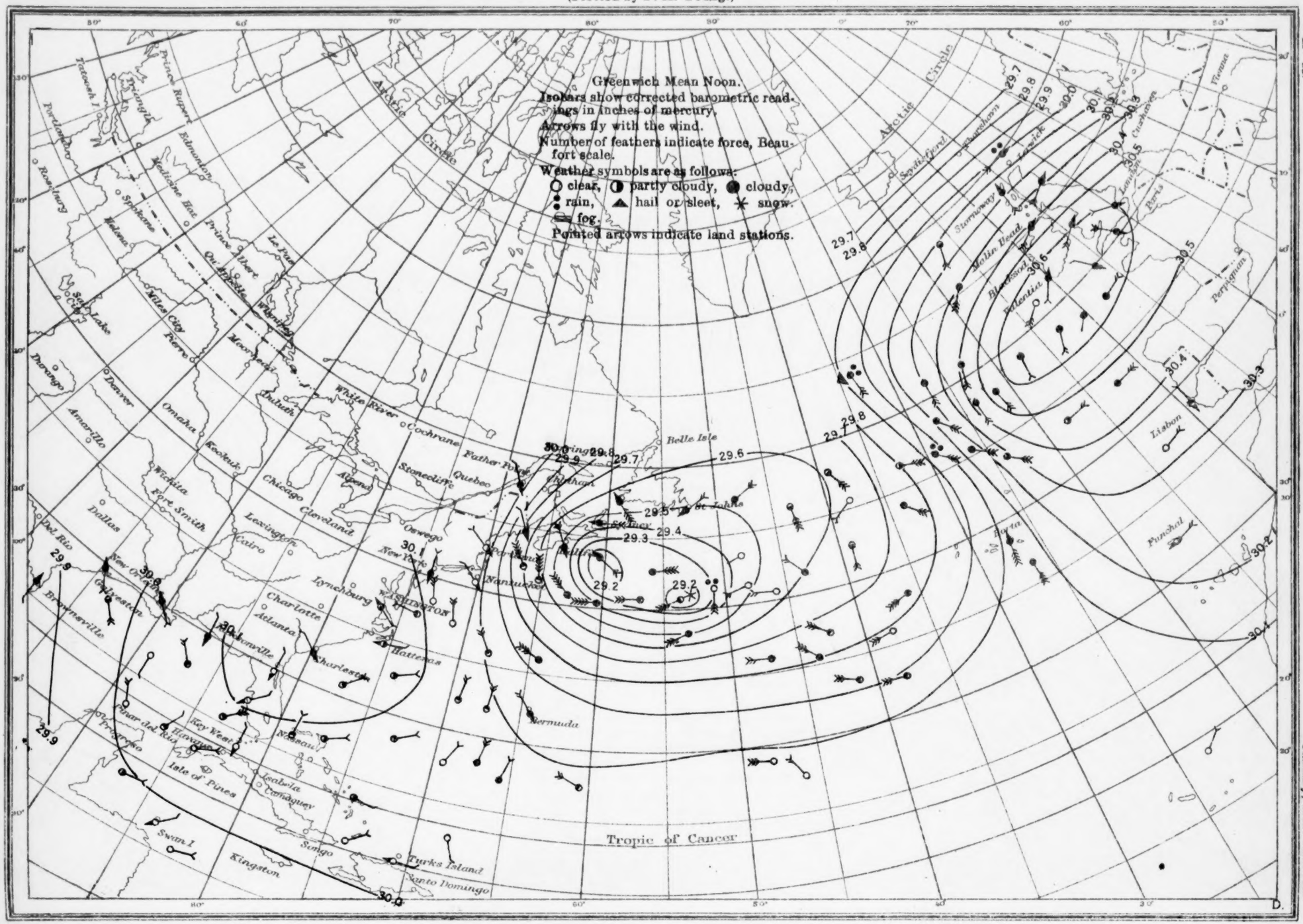

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow.
fog.
Pointed arrows indicate land stations.
Tropic of Cancer
Arctic Circle
Bermuda
Nassau
Kingston
Turks Island
Santo Domingo
Belle Isle
St. Johns
Halifax
Harrington
Cochrane
Father Point
Quebec
Stonecliffe
Chatham
Sydney
Portland
Buffalo
Toronto
Parry Sd.
Duluth
White River
Moorhead
Winnipeg
Prince Albert
Edmonton
Medicine Hat
Swift Current
Prince Rupert
Port Simpson
Tatoosh I.
Roseburg
Spokane
Helena
Miles City
Pierre
Omaha
Keokuk
Chicago
Cleveland
Denver
Amarillo
Dodge City
Wichita
Fort Smith
Dallas
Del Rio
Galveston
New Orleans
Brownsville
Jacksonville
Charlotte
Atlanta
Lynchburg
Washington
Hatteras
Charleston
Key West
Havana
Pinar del Rio
Isabela
Camaguey
Swan I.
Lexington
Cairo
Abilene
Parkersburg
Pittsburg
Erie
Oswego
Rochester
Albany
Boston
Portland
Eastport
Father Point
Yarmouth
Sydney
Belle Isle
Harrington
Cochrane
Stonecliffe
Quebec
Chatham
St. Johns
Halifax
Bermuda
Nassau
Kingston
Turks Island
Santo Domingo
Swan I.
Key West
Havana
Pinar del Rio
Isabela
Camaguey
Charlotte
Atlanta
Jacksonville
Charleston
Hatteras
Lynchburg
Washington
Parkersburg
Pittsburg
Erie
Oswego
Rochester
Albany
Boston
Portland
Eastport
Yarmouth
Sydney
Belle Isle
St. Johns
Halifax
Harrington
Cochrane
Father Point
Quebec
Stonecliffe
Chatham
Toronto
Parry Sd.
Duluth
White River
Moorhead
Winnipeg
Prince Albert
Edmonton
Medicine Hat
Swift Current
Prince Rupert
Port Simpson
Tatoosh I.
Roseburg
Spokane
Helena
Miles City
Pierre
Omaha
Keokuk
Chicago
Cleveland
Denver
Amarillo
Dodge City
Wichita
Fort Smith
Dallas
Del Rio
Galveston
New Orleans
Brownsville
Jacksonville
Charlotte
Atlanta
Lynchburg
Washington
Hatteras
Charleston
Key West
Havana
Pinar del Rio
Isabela
Camaguey
Swan I.
Kingston
Turks Island
Santo Domingo
Bermuda
Nassau
Tropic of Cancer
Arctic Circle
Reykjavik
Stornoway
Valentia
Lerwick
Thorshavn
Skudesnes
Lerwick
Stornoway
Valentia
Skudesnes
Thorshavn
Reykjavik

Chart XIII. Weather Map of North Atlantic Ocean, January 26, 1923.

(Plotted by F. A. Young.)